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TABLE OF LEADING ARTICLES.

Rainy Day Problems at Panama.................. 709
The Education of Engineers..................... 710
The Diversion of Water to Distant Consumers...... 710
The Cataract Dam of the Water-Supply System of Sydney, New South Wales. (Illustrated)......... 712
The Cost of Preventing Boiler Scale............... 714
An Electrically-Operated Dredge. (Illustrated)..... 715
The Big Lazer Creek Bridge. (Illustrated)........ 716
Heating and Ventilation of a Large Retail Store in San Francisco. (Illustrated)................... 717
An Early American Cast-Iron Arch Bridge. (Illustrated) 719
The Marble Finishing Building of Maltby & Sons, Buffalo, N. Y. (Illustrated)..................... 719
The Clogging and Cleaning of Water Mains........ 720
An 11,000-kw. Turbo-Generator Station in Seattle, Wash. (Illustrated)........................... 721
Direct and Indirect Methods of Electrical Purification of Water..................................... 725
A Combined Refuse Destructor and Electrical Generating Station in England. (Illustrated).......... 726
Factory Building of the Rushmore Dynamo Works, Plainfield, N. J. (Illustrated).................. 727
Operating Results of the Producer Gas Pumping Plant at St. Stephen, N. B. (Illustrated)......... 727
Conservation of Life and Health by Improved Water Supply. (Illustrated) 730
A Tall Concrete Smelter Chimney. (Illustrated).... 735
The Treatment of Railroad Ties and Materials Available for this Purpose in New Jersey.............. 736
Garbage Disposal in Cleveland..................... 736
The Blackwell's Island Bridge...................... 736

Rainy Day Problems at Panama.

The canal work going on now at the Isthmus of Panama is far more interesting than anything done heretofore, for the present rainy season, which will last for the remainder of the year, will thoroughly prove the ability of the organization there to overcome the difficulties that have given the Isthmus its notorious character. No one who has personally witnessed the manner in which the work is going forward now will be at all apprehensive of the successful prosecution of the undertaking. In spite of the magnitude of the operations, their details have been developed until everything moves along with the precision of clockwork, even in the face of tropical downpours and sudden floods in the rivers. The operations are now being conducted like those of a victorious army in the field. There may be a check in some place, a withdrawal in another place, but the general movement is steadily forward and shows everywhere the guidance of a master spirit. The Isthmus is a long distance from the United States, however, and if the amount of excavation should fall off during a number of consecutive months, some people may form an opinion that disaster threatens the enterprise. It is unfortunate in one way that so much attention has been drawn to the monthly excavation records in the past, for they are liable to be influenced by so many causes that a succession of low monthly outputs is entirely possible, but will be of trifling real significance, however disturbing it may be to the observer unfamiliar with the working conditions.

It is generally considered that the construction of the canal is a matter of excavation, aside from the Gatun dam and the three sets of locks. This view of the problem is correct, but is misleading on account of the peculiar conditions surrounding excavation on this Isthmus. There are some places along the line where the material excavated can be hauled to dumps only a short distance away, but the average haul from the Culebra Cut is already more than 10 miles for each spoil train. This statement will not mean very much, except to those engineers and contractors familiar with heavy excavation, who will understand something of this part of the work when it is borne in mind that during April the total steam shovel excavation in the Culebra division was over 1,242,000 cu. yd., and it was this enormous output which had to be hauled more than 10 miles before it could be dumped. The question naturally arises why such an excessive haul is necessary, and the answer to this question can only be fully appreciated after a visit to the Isthmus. After going over the line a few times it will be apparent that the number of places where the excavated earth and rock can be dumped outside of the canal prism is limited. In certain places along the line there are dumping grounds just about large enough to receive the materials excavated in the immediate vicinity, so that the problem of excavation and fill there is not very unlike that of the average railroad. But at the Culebra Cut, where excavation is proceeding on many levels, only the material from the upper levels can be sent to near-by dumping places, on account of the prohibitory grades which would be necessary to get cars from the lower levels to them, and also on account of the limited capacity for receiving spoil of these places. The problem of excavation is, therefore, intimately associated with that of dumping grounds, and a great deal of attention has been paid during the past year to the selection of these sites so as to reduce the cost of transportation to a minimum. Even with the study devoted to the subject a large amount of the material has to be transported long distances.

To understand the transportation problem, it is necessary to visit the Isthmus at the beginning of the rainy season, before everything is in complete shape for resisting the effects of the daily tropical rainstorms. During the dry season the tracks can be maintained without difficulty, but as soon as the storms begin, the material in the cuts assumes an intensely sticky, slippery character. The passage of the numerous spoil trains over the tracks quickly pounds this sandy clay into a half-liquid mud, on which the crossties slide about at the slightest provocation. It is, accordingly, necessary to ballast all tracks, except loading tracks, with broken stone, at the beginning of the wet season, for if this is not done the whole transportation system will soon be tied up. At the present time there is something like 145 or 150 miles of construction tracks in use in the Department of Excavation and Dredging, of which about 10 per cent. is shifted each month, figures which show the extent of the track-maintenance problem. The difficulties are enhanced in the Culebra Cut by the land-slides, which are more troublesome than was anticipated. When one of them begins, nobody can tell when it will end. The phenomenon is more like a glacial flow than an ordinary landslip. The material does not cave in or slide forward from the top, as a rule, but a whole hillside slips slowly downward to the canal prism. When one occurs not only steam shovels and loading tracks are thrown about, but sometimes the main transporting tracks are so interfered with that a good deal of trouble results. The present season will probably demonstrate better than the 1907 rainy season just what is to be expected from these occurrences. They are certainly not insurmountable nor need they cause any apprehension concerning the maintenance of the canal after it is opened to navigation, but they will increase the anticipated cost of the work and materially strengthen the arguments against the construction of a sea-level canal.

Another feature of the transportation problem, equally important with the maintenance of the running and the loading tracks in the cuts, exists on the dumps. So far as the total output from the shovels is concerned, it makes no difference whether trains are held up on the dumps, on the running tracks or on the loading tracks; the effect is just the same in keeping the shovels idle. The problem on the dumps is a difficult one for two reasons, the excessive rainfall and the character of the materials which form the dumps. This material is either a slippery clay or an argillaceous sandstone which becomes very slippery when exposed to the weather. In many places the dumps settle and slide in a few hours to such an extent that it is impossible to run trains over some of the tracks, and consequently these settlements may delay operations materially. In addition to this complication the heavy rainfall reduces the dump surface to the condition of half-liquid mud, and it is just as difficult to keep the tracks in condition as it is in the cut. It is the practice to ballast all the important tracks on the larger dumps, and even the dumping tracks are ballasted somewhat in some places. It is important to bear in mind, therefore, that the excavation of the canal is not simply a question of keeping enough steam shovels at work, but is a far more complicated problem, involving the management of running lines and the maintenance of a large number of dumps. Although the work is a complex one and likely to be interrupted temporarily, it is absolutely certain, however, that it can be completed as soon as the dam and locks.

These remarks may sound somewhat dismal, but the engineer who will take the time to visit the Isthmus during the rainy season will see very little there which is indicative of lack of spirit. With the possible exception of a few track foremen, whose experience has been gained in the tropics on roads where the maximum traffic probably does not exceed half a dozen trains daily, the whole construction army seems to be happy and contented, confident in the successful outcome of their work, and taking a just pride in their share of it. No other feeling than this would keep men at work in the cuts and on the dumps during tropical down-pours, when an exposure to the rain for a couple of minutes results in a complete soaking from head to foot. A couple of years ago all work would stop, as a rule, whenever the rain amounted to enough to stop a baseball game in the States; at the present time rains will stop nothing provided work has to be done. This exposure to the elements apparently brings no injurious results to the health of the men, and the fact that they willingly submit themselves to it is eloquent testimony to the spirit that animates everybody connected with the great enterprise.

The Education of Engineers.

At this season of the year, when the various schools of engineering of the country are sending forth young men to begin their professional careers after a more or less effective educational training, it is natural to expect some comments on the subject of engineering education, although it has probably been discussed as much as any other one topic connected with the profession of engineering. It is a subject on which there is room for practically infinite variety of opinion, usually stated with the confidence of certain knowledge, even though that certainty may not be born of very extended experience in the work of instruction. Although the result is almost a discouraging maze of diverse judgments, these differing comments aid in materially improving the quality of professional educational training given to engineers from year to year. This lack of harmony of judgment upon so important a topic has its advantageous side, and is by no means characteristic of the opinions of those alone who have not had experience in the class-room, for the annals of the Society for the Promotion of Engineering Education show at least an equal divergency of views on the part of the engineering instructors of the country.

It has been quite customary to indulge in certain trite and hackneyed forms of caution or advice to young engineers in beginning their professional careers to the effect that they have not yet attained to the sum of all engineering knowledge, and that it is scarcely reasonable for them to expect the position of chief engineer to be offered to them before they have had some experience in the practical work of life, all of which, of course, is intended as the admonition of a superior, perhaps, to an over-ambitious subordinate. To the great majority of instructors who have been engaged for any considerable length of time in teaching engineering students, such admonition or patronizing advice seems both highly unnecessary for the young engineer, and not altogether creditable to his elders who too frequently assume this attitude of superiority. As a matter of fact, the effect of the instruction received in the best engineering schools of the country at the present time is, among other things, distinctly in the direction of giving to the young engineering graduate a correct perspective of his real relation to his future career. There are manifestly some exceptions to this statement, perhaps many in the aggregate, but the percentage which represents them is certainly small. There is probably no one feature of the educational training of young engineers which is impressed upon them more frequently or more forcibly by the average instructor than the fact that what they learn in the class-room is at best but the beginning of their actual preparation for professional accomplishment, although a most important beginning and not extravagantly characterized at this time as an imperative preparation for their best work. In other words, it is very rare that any engineering student acquires in the class-room any undue or exaggerated appreciation of his own qualifications for the actual work before him. It is well that he should have a sufficient appreciation of what he learns to create in him a reasonable degree of confidence and self-reliance so fundamentally essential for effective initiative in all professional work really worth doing. When, therefore, an occasional experienced practitioner expresses a desire to have the young engineer "dehorned" before being taken into his employ, it is not unlikely that the misfortunes of his contact with young engineers may have arisen at least partly from his desire to exhibit practical smartness to the novitiate.

It can scarcely fail to be evident to any one who takes the trouble to examine closely the quality of professional education now given to young engineers that the latter are exceedingly fortunate in at least two opposite characteristics of the educational training which they are receiving. Reference is here made both to the mathematical or so-called theoretical instruction which they are given, and to the well-considered exercises which they perform in the applications of those analyses to the actual works of the engineer. It is not to be thought for a moment that any engineering school in the country is perfection in either of these respects; but the frequent discussion and comment to which engineering education has been subject during the last few years has certainly had the effect of demonstrating conclusively the necessity for both these lines of educational work in the technical schools. Much has been said and written about the character of mathematical exercises which should be given to the engineering student, some of which is wise and has judiciously affected the corresponding instruction work and some unfortunately has been of less excellent character, but fortunately without much effect. It has come to be generally recognized that the precision and accuracy of mathematical work may be and are made the means of most admirable mental training needed above all things by the engineer. At the same time it is equally well admitted that the purpose of mathematical training is not that of abstract mental gymnastics, but is to afford a means by which various elements of engineering problems may be so handled or treated as to enable the professional man to reach the best possible solution in view of all the actual conditions of his work. And this brings one to the so-called practical side of educational training, which has been most effectively developed at the present time.

There are few, if any, courses of engineering study in the country in which the student is not well and wisely drilled in the application of his purely analytic work to the general problems of engineering, whether that be in the broad field of civil engineering or in the special fields of the manufacture, transmission and application of power. This is not by any means saying that the practical work of the field, of the office or the shop can be wisely or otherwise brought into the class-room, for it cannot be. The sooner an instructor realizes this fundamental fact and governs his practical work of instruction accordingly, the sooner will his work be effective and successful. The engineering school is not the place where the young engineer is to gain his experience, his subsequent life-work is the only place where he can get that, but rather it is to acquire the analytic or philosophic basis for his actual professional work without which that work can never be well rounded or fully effective. In this direction the educational training of young engineers has been remarkably developed within the past twenty-five years and is being still developed. Engineering instructors as a body realize these fundamental truths, and fortunately for the profession are shaping their work to even higher and more effective results than they have already accomplished. Indeed, their work has come to be the true basis of the profession as it now stands.

The Diversion of Water to Distant Consumers.

A few months ago attention was called in this journal to the suggestions made by a Royal Commission in Great Britain that the water supplies of the country should be controlled by river-district boards supervised by a national commission, so that all water might be utilized to the best advantage and be distributed equitably among different consumers, whose numbers are increasing so rapidly that their water supply has become a complicated problem. A somewhat similar situation has arisen in the northeastern part of the State of New Jersey. There a considerable number of private companies and municipalities are supplied by the East Jersey Water Co. with water taken from the Passaic River. It is only by a very liberal construing of the term that some of these consumers can be considered as being in the Passaic valley. The company mentioned is not universally popular and as a result of feeling against it a suit was brought by the City of Paterson some two years ago to prevent any further diversion of the waters of the river. A preliminary decision was handed down by the court of equity of the State a couple of weeks ago and although it is not complete, further hearings to settle minor points being necessary, it is a confirmation of the views expressed by courts in other States, that water must not be diverted from the drainage area of a stream to supply consumers outside of that area, provided such diversion affects the rights of lower riparian owners.

The city of Paterson brought suit as a riparian owner on the ground that it was the owner of property on the Passaic River some of which extended to the center of the river bed and other portions merely to the water's edge. The court ruled, and this decision may become an important precedent under certain conditions, that riparian ownership as far as the edge of the stream is as effective as ownership of the river bed in giving a right to the flow of the river subject only to the diminution incident to lawful and reasonable uses of the water by upper riparian owners or those claiming the privilege of such use by lease. The New Jersey Court of Errors and Appeals has recently decided that a diversion of the waters away from the riparian lands for the purpose of sale does not fall within the lawful and reasonable uses permitted to riparian owners. Such diversion for purposes of sale is now held to be a violation of the right of the riparian owner, according to Vice-Chancellor Emery, even without proof of any actual perceptible damage. When such a right of diversion is claimed, as in this case, and for long periods of time and in considerable quantities, the complainant is entitled to equitable relief for the purpose of preventing the acquisition by the defendant of any adverse right of apropriation, independent of any question of present damage. He makes the further important ruling that the effect of the diversion upon the riparian lands must be determined by a comparison of its amount with the low-water flow of the river and not with its average flow, including floods and high water. On this basis the quantity diverted by the East Jersey Water Co. is held to amount during times of low water to an appreciable diminution of the stream, so considerable that equitable relief cannot be denied to the city of Paterson.

The issue of an injunction is the ordinary protection given a riparian owner to prevent any further infringement of his rights by the diversion of water or by its pollution by upper riparian owners. The effect of the injunction, as is well known, is to prevent any continuation of these unlawful acts. It is self-evident, however, that an injunction will work great harm in some cases, shutting off the supply of water to communities which depend upon it solely or in other cases absolutely preventing the use of sewerage systems. Accordingly the courts, in such cases, substitute for an injunction the award of compensation to the injured parties. In the present case the court rules that so far as any increase in the quantity of water diverted is concerned, the city is entitled for its future protection to an injunction restraining such increase except under certain conditions, which are mentioned. The fixing of equitable terms and conditions of enjoining the present diversion, however, including the question of the time when it should be directed to begin, involves many special inquiries, both as to law and facts, on which the parties to the suit must be further heard. The complicated nature of a case of this sort in a district which is well settled is shown by the nature of the inquiries which the court directs to be made. In the first place, it is considered desirable to determine whether the diversion during periods of low-water in the river should not now be enjoined, except for municipalities formerly obtaining their supply from the Passaic River below Paterson, which have been obliged to abandon this source of supply because of the pollution of the river by the sewage of that city. It is suggested that an injunction need not be directed against the supply of water by the company to these communities until after the city of Paterson has ceased to pollute the river. It is also suggested that an inquiry should be made as to whether any of the corporations supplied with water by the East Jersey Water Co. has the right of condemning water rights in aid of the company's diversion; if so, it might be well to hold back any injunction against such consumers until they have had a reasonable time to carry out condemnation proceedings. It is further suggested that in the case of municipalities not now having such right of condemnation, the injunction might be withheld until after the termination of the next session of the legislature, in order to give them an opportunity to apply for such a right. This course has been adopted in other cases where an immediate injunction would destroy the sole supply of water and thus imperil public health. An inquiry is also suggested concerning the complications of the water supply of the city of Paterson itself. The Passaic Water Co. takes its supply from the river and delivers it to the East Jersey Water Co. to be purified and returned to it; it then supplies the city of Paterson with this filtered water. It is evident that this situation is a complicated one, for if the city insists upon an injunction against the East Jersey Water Co. it may shut off its own water supply. The vice-chancellor further suggests that arguments should be produced as to whether any injunction now issued against an increase of the quantity of water diverted from the river should not allow an increase necessary from growth of population or otherwise during the time for which the injunction against the diversion of the present supply may be suspended.

Attention is called to all these complications because they illustrate the unfortunate condition of water supply undertakings certain to arise with the growth of population in any district of limited extent. Water is rapidly becoming a pretty valuable article in a good many sections of the country. Large cities demand enormous supplies and in going far afield for them are likely to enter drainage areas which cannot by any stretch of the imagination be considered a part of the catchment basin on which they are located. The situation in northeastern New Jersey is practically the same as that in eastern Massachusetts, and complications of a different character, but equivalent effect, exist in southern California. As a result, the engineer interested in water supply undertakings is likely to find himself seriously hampered before long by a snarl of judicial precedents and undigested laws which prevent the utilization of water resources to their utmost capacity. As situations of this sort become more apparent and their restraint on the development of towns and cities becomes evident, it is but reasonable to anticipate a thorough overhauling of our laws regarding water supplies in order that the subject may be put upon a simple and equitable basis and the conservation of water resources may be attended to by commissions making a specialty of such work. The time has gone by in a number of well-settled districts when the independent development of water resources should be permitted longer.

Notes and Comments.

The Portland Cement Tenders recently opened by the Isthmian Canal Commission, which are summarized in the Current News Supplement of this issue, are the most important ever submitted for an American enterprise, and will be examined with great interest, particularly as foreign cement manufacturers were permitted to bid. The enormous quantity of cement called for, the fairness of the specifications, the reliability of the purchaser, and the outlook in the construction fields in this country and Europe, all tended toward bed-rock quotations.

The Protection of Steel Reinforcement by the concrete in which it is bedded has been investigated by the National Physical Laboratory of Great Britain, and the results of the experiments there confirm the observations made previously by many engineers. The tests show that both bright steel bars and those bedded in the concrete without removing the scale from them are thoroughly protected from rust, even though the concrete is covered with water several times a week for a year and afterwards left in the open air for three months. These tests are particularly important, coming from the National Physical Laboratory, because the Local Government Board of Great Britain has shown itself extremely conservative in the matter of permitting the use of reinforced concrete.

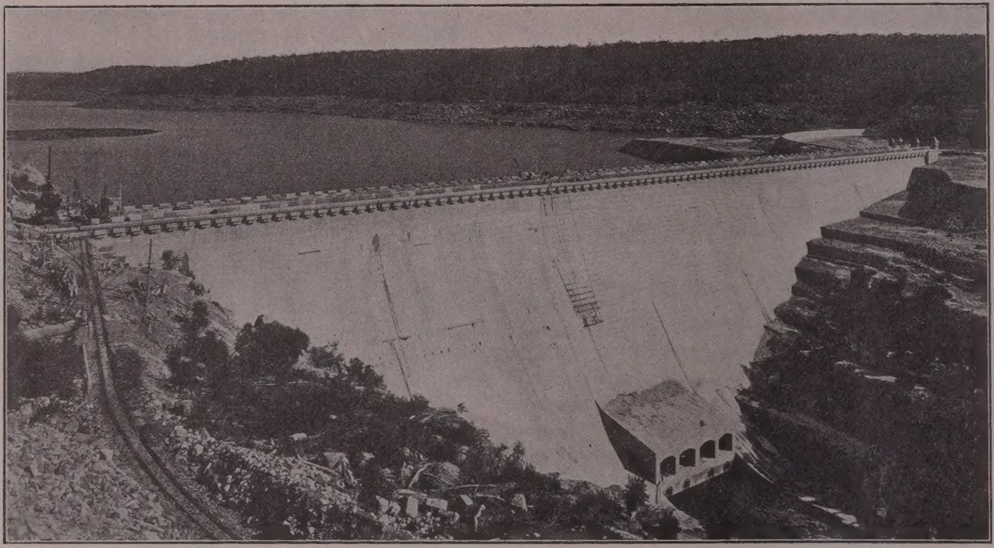
The New York State Highways are to be managed after this year by an entirely different organization from that hitherto in charge of them. An act recently signed by the governor places the control of this work under a State Highway Commission, consisting of three members, each serving six years. The chairman will have a salary of $6,000 and the others $5,000 each. The law requires one of them to be a civil engineer experienced in the construction of highways and bridges, and one of the commissioners must be a member of the minority party. There will be two deputy commissioners, each receiving $3,500 a year, both of whom must have had experience in road building. One of these deputies will be in charge of State and county highways and the other in charge of town highways and bridges. The new law provides for four distinct classes of highways: trunk roads connecting important cities and built entirely at the expense of the State, county roads connecting the important points in each county and constructed at the joint expense of the State, county and towns traversed, town highways connecting various points in each town with the county highways and built at the joint expense of the State and the towns, and local roads, built entirely by the towns. It will be seen that a marked change in the new law is the construction of main roads entirely at the cost of the State. Nearly forty different routes are specified for the trunk highways and many of these routes are very long. Three of them run from New York City toward Albany, and another lies through the southern counties of the State between Buffalo and New York. In constructing these main roads the Commission is authorized to abolish all grade crossings, and in building county highways it has the same privilege. The law does away with the "labor system" of road work and substitutes the "money system." The latter is strongly in favor in most parts of the State, even where it has not yet been adopted, although but a comparatively short time ago it was bitterly opposed. The construction will be under the charge of six division superintendents, each of whom must be a civil engineer and will be paid $3,000. Under the division superintendents there will be the county or district superintendents, who will be in charge of the work in their respective counties or groups of counties. The lowest officials will be the town superintendents, responsible to the district or county superintendents. These town superintendents are authorized to request the services of county prisoners for highway work. The new Commission is given power to regulate the widths of tires and to prohibit the use of chains or armored tires on automobiles. The new law is the result of an active campaign carried on by officials of a number of counties not satisfied with the operation of the laws now in force. Whether the changes will be beneficial or not can only be determined by the test of time. A great deal will depend, of course, upon the character of the men appointed as commissioners by the governor and upon the character of their staff. The proposed organization is a decidedly expensive one, and the distribution of the cost of the highway work between the State, the counties and the towns will throw a much larger burden of the cost of good roads upon the larger cities, the main contributors to the State's funds, than has been the case in the past. There may therefore be a tendency to build the through roads, constructed entirely at the State expense, and to delay the construction of the subordinate roads, which must be paid for in whole or in part by the local taxpayers. Consequently, when the Legislature happens to be of a liberal turn of mind, State roads will probably be materially encouraged, while during periods of legislative economy the construction of roads depending on State aid will practically cease. Taken all in all, the new law must be looked upon as something of an experiment.

The Subway Situation in Greater New York has been somewhat changed by the action of the Interborough Rapid Transit Co. last week in offering to build the equivalent of two sections of the so-called Fourth Avenue subway in Brooklyn for the sum of $1,200,000, very much less than the actual cost of construction. Contracts for building six sections of this subway have been awarded, but a good many people believe that the actual completion of these contracts is likely to be a remote event, for a number of reasons that need not be discussed again at this time. The offer of the Interborough company to construct a subway from its present line in Flatbush Ave. to the new Manhattan Bridge and over that structure to a connection with the Third Avenue elevated line at Canal Street and the Bowery, Manhattan, is as advantageous to the city as to the company. It means the saving of several million dollars to the city by rendering unnecessary the construction of two sections of the Fourth Avenue subway, and at the same time, under the company's promise to give transfers from the new line to the Manhattan elevated road, the citizens are insured a very long ride through two boroughs for a single five-cent fare. Moreover, this proposed route will utilize the Manhattan Bridge, something that is greatly to be desired in order that the Brooklyn Bridge may be relieved of a considerable part of its present traffic. Two criticisms have been made regarding this project: the first is that municipal ownership is absolutely essential and that any extension of the present hold of the Interborough Rapid Transit Co. upon the subways of the city should not be permitted, and the second is that the company's proposal provides only for a double-track subway, although a four-track subway is bound to be needed within a comparatively few years. Whether this last contention is a valid one or not can only be settled by a careful study of traffic conditions which this journal has not made. It has no sympathy, however, with the claim that there is something so desirable in the mere fact of municipal ownership that the many advantages of the Interborough's offer should not be accepted.

THE CATARACT DAM OF THE WATER-SUPPLY SYSTEM OF SYDNEY, NEW SOUTH WALES.

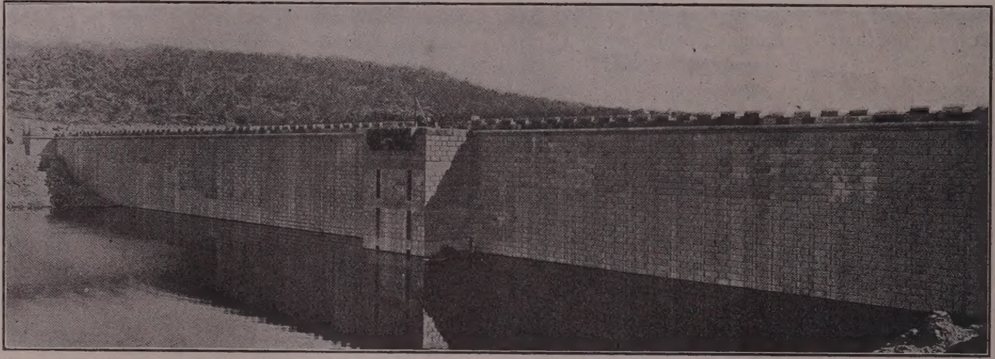
A large concrete and stone masonry dam, involving various notable features of design and construction, has recently been completed in connection with the water-supply system of Sydney, New South Wales. This city, which has a population of over 500,000, obtains its supply from the Nepan and Cataract Rivers, with an available catchment area of 354 sq. miles. The average rainfall of about 50 in. a year over this area assures an adequate quantity to provide for a large growth in population, but an original reservoir at Prospect only impounded 5,446,000,000 imp. gal., which renders available an average of 20,000,000 imp. gal. per day, including the flow of the streams. For several years the water in this reservoir was drawn down during occasional droughts until it became evident that a further supply had to be developed. In fact, in 1902 a specially severe drought caused the water level in the reservoir to fall below the intake of the conduits leading from the latter to the city so that water had to be pumped into these conduits for 3 months. This condition of affairs resulted in a decision to secure an additional supply an an emergency measure.

Since the water is delivered from the two rivers to the Prospect Reservoir by a system of canals and tunnels having a capacity of 150,000,000 gal. per day and the flood flows of the stream are much greater than that quantity, such flows could not be utilized fully. The conclusion was therefore made to develop the water-shed fully by the construction of another dam. Following a thorough investigation of various projects by a Royal Commission, a site was selected 40 miles above the Prospect Reservoir and just below the confluence of that river with the Loddon River, at a point 50 miles southwest of Sydney. A reservoir having a total impounding capacity of 21,411,500,000 gal. has been developed by a dam at this site. This reservoir extends up the valleys of both rivers, with an extreme length of 19 miles and an area of approximately 2,400 acres. It further develops a portion of the water-shed tributary to the Prospect Reservoir, and will be used to maintain the level in the latter at or near the high-water mark.



Downstream Face of the Completed Dam.

At the site of the dam the river passes through a narrow gorge with precipitous sides of sandstone rock. This rock is of fairly good character, and as it is near the surface entirely across the site, a very satisfactory foundation was secured for the dam. The cross-section of the latter resembles closely that of the new Croton Dam of the water supply system of New York City. The sandstone was excavated until all seams and fissures had been followed out, a maximum depth of 35 ft. below the bed of the river being reached. As the dam rises to a maximum height of 157 ft. above the bed of the river, its total height is therefore 192 ft. from the base to the top. The extreme length of the dam at the crest is 811 ft., its top width is 16½ ft., and its extreme bottom width 158 ft., with a maximum depth of water of 150 ft. The body of the dam is composed of Cyclopean rubble masonry, consisting of blocks of sandstone weighing from 2 to 4½ tons, built to break joints both vertically and horizontally and to have a maximum amount of bond. These stones are imbedded in cement mortar, while the vertical joints between them are made with concrete. The proportion of blocks to concrete and mortar is approximately 6.5 to 3.5. The upstream face of the dam consists of 2.5 x 2 x 5-ft. concrete blocks, imbedded in and jointed with cement mortar made in the proportions of 375 lb. of cement to 7½ cu. ft. of sand. Between the facing of concrete blocks and the mass of masonry is a layer of concrete having an average thickness of 3 ft. The downstream face of the dam is of concrete 6 ft. thick.



Concrete Block Facing on the Upstream Face of the Dam

A spillway 715 ft. long is built at one end of the dam to carry flood waters and prevent the structure being overtopped. The crest of this spillway is about 150 ft. above the bed of the river, the discharge over it being carried in a channel about an ⅛ of a mile long before it joins the river again. As the crest of the dam is about 7 ft. above the crest of this spillway weir, it is believed that ample precaution is made for any flood that may ever occur. The spillway and the channel extending from it to the river below the dam are entirely in rock excavation.

Sandstone blocks used in the masonry of which the entire dam between the two faces is composed were quarried as large as it was practicable to handle it with the available equipment, and were hewed to a rough rectangular form. No stone was less than 2 ft. in depth, nor was allowed to contain less than 20 cu. ft. when measured on its smallest dimension. Each stone was roughly picked to a true surface on its bed and no stones having a concave bottom surface were accepted. The remaining faces of the block were cut to approximately vertical and horizontal planes. The stones were used as they came from the quarry and were thoroughly washed before being laid, with a water jet not less than ½ in. in diameter working under a head of at least 100 ft. They were also thoroughly wetted immediately before they were laid, in order that they would not take up moisture from the mortar and concrete with which they came in contact. The stones were selected of such height as to avoid horizontal jointing and were generally laid on their natural bed, although where it appeared advisable, in order to obtain a maximum of irregularity in height, this rule was not followed.

Three classes of concrete were used during the construction, as follows: the upstream facing blocks, the lining of vertical shafts leading to a gate chamber and all surfaces exposed to water were composed of concrete in the following proportions: 375 lb. of cement, 7½ cu. ft. of sand, 15 cu. ft. of bluestone and screenings; the bluestone and screenings were in the proportions of 3 parts of 2½-in. stone to 2 parts of ¾-in. screenings. The outside of 4-ft. blow-off pipes, a lower valve chamber, the filling for cut-off trenches and tunnels and the roof of a valve chamber on the down-stream side of the dam were all composed of concrete in the proportions of 375 lb. of cement, 10 cu. ft. of sand and 20 cu. ft. of bluestone and screenings, the stone and screenings being in the same proportions and sizes as for the concrete previously mentioned. The concrete in the downstream face of the dam, in the larger voids in the mass of the dam and between the facing blocks on the upstream side and the main part of the structure was made in the proportions of 375 lb. of cement, 11½ cu. ft. of sand and 20 cu. ft. of 3-in. stone; bluestone was used in most cases for this concrete, but approved sandstone was occasionally accepted in lieu of it. Besides the special mortar used in bedding the upstream facing blocks, a mortar consisting of 375 lb. of cement to 12½ cu. ft. of sand was used in bedding the stone in the mass of the dam and where the space between stones was too small for the third class of concrete.

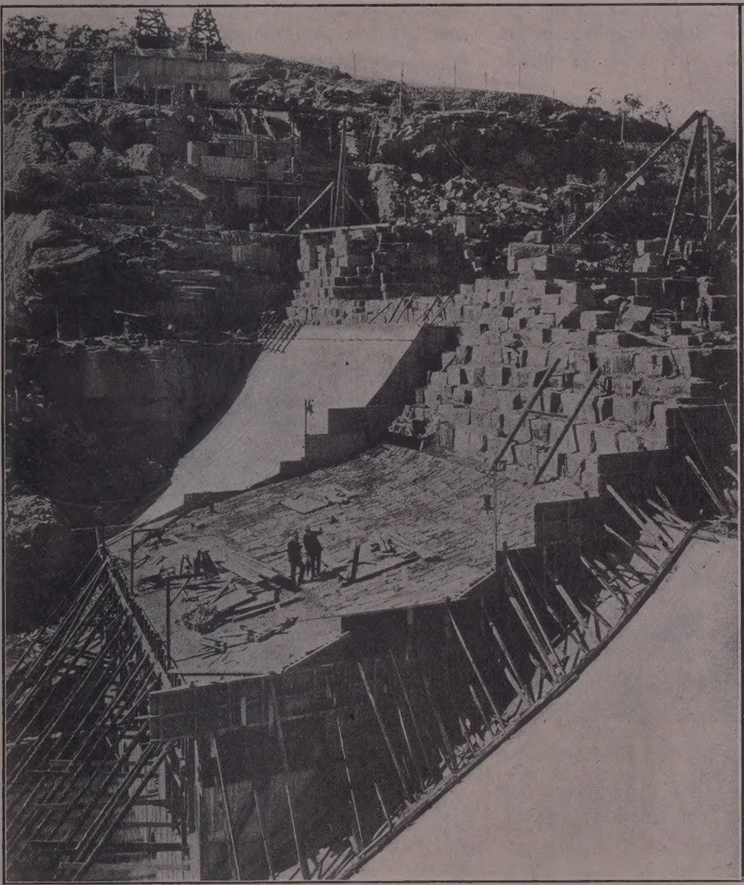
The sandstone used in the blocks forming the mass of the dam weighed 140 lb. per cubic foot, and a 12-in. cube of it showed a crushing strength of 276.3 tons per square foot. This sandstone does not resist the action of weather very well, although frost occurs only for a few days in each year. The faces of the dam were accordingly built of concrete to protect the interior masonry from deterioration. A very complete system of drains was also introduced in the body of the dam, in order to collect and carry away any water that may penetrate into the latter. These drains are located immediately behind the concrete blocks forming the upstream face of the structure, and connect at intervals with pipes leading through the entire height of the dam from the upstream to the downstream face where they discharge. The flow from these drains with a depth of 106 ft. of water against the dam is said to be slight and the structure is said to be remarkably dry. Expansion joints were introduced in the concrete facing of the dam at intervals, with a view of confining the temperature cracks to these joints. No such cracks had developed at the time the data for these notes was collected, and it is believed that the large blocks of stone used, together with the bond obtained, have distributed so fully the stresses due to changes in temperature, that no such cracks will result. Furthermore, the upper portion of the dam, in which such cracks might be expected, was completed during cold weather, a condition that would tend to reduce temperature cracks. At the same time, as has been stated, frost generally occurs for only a few days each year.

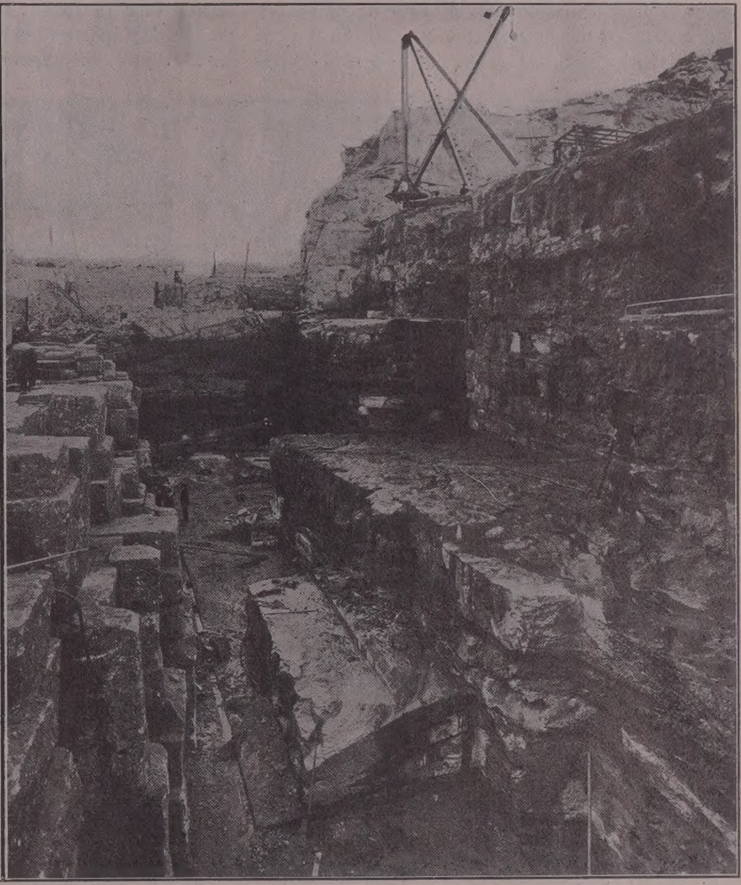
The preliminary construction work was started with a force of day laborers under the direction of Government officials in October, 1902. These forces constructed highways, opened quarries, built construction railroads, designed and established all the construction plant and made a large part of the foundation excavation, in addition to clearing the reservoir site. A considerable quantity of concrete was placed in the foundations and some of the mass stone masonry was built by force account. A contract for the completion of the construction of the dam within a period of two years, the contractors to have full use of the plant that had been installed, was awarded to Messrs. Lane & Peters in April, 1905. The work that had been done under the supervision of the government officials and the plant that had been installed to handle this work was described in The Engineering Record of November 5, 1904. The plant covered in that description was used throughout the balance of the work, so will be referred to here only in outline.

Two 1,200-ft. span Lidgerwood cableways, each with a capacity of 4½ tons, were set up parallel with the axis of the dam in such a manner as to command the site of the latter. One of these cableways was swung from traveling towers and the other for stationary towers, both being electrically operated by 53-in. double-drum hoists, driven by two General Electric direct-current motors with series-parallel controllers. The hoists were arranged to handle light loads at high speed and the cableways were capable of operating at the rate of 30 trips per hour. The excavated earth and rock and the materials for the masonry were handled by these two cableways, several stiff-leg derricks and traveling locomotive cranes. The sandstone used in the body of the dam was taken from two quarries, one at each end of the site. The materials were transported to and from the cableways on berms formed on the sides of the valley. A Gates crusher, with a capacity of 40 tons an hour, was installed at a quarry six miles from the dam, where stone was obtained for the concrete, and a narrow-gauge railroad was built to deliver stone from this quarry to the site. The cement was delivered to the work from a railroad station, 16 miles distant, in wagons hauled by traction engines and by teams. Sandstone suitable for crushing was obtained about a half a mile away, at which point crushing and sand-washing plants were installed to furnish sand for the concrete.

Two electrically-driven cubical concrete mixers were set up at one end of the dam in a position permitting materials to be delivered to them readily, and concrete to be handled from them to the cableways, or to the yard in which the concrete facing blocks were cast. The mixers discharge into portable buckets which were handled from them to the block yard or to the point where the cableways and derricks could reach them on 4-wheel trucks running on narrow-gauge tracks.

The block yard was laid out on a level space and was entirely floored over. A number of parallel tracks for a traveling crane were placed lengthwise of this yard with their rails about level with the top of the molds for these blocks. The trucks on which the buckets were delivered to the yard from the mixers operated on the same rails which carried the trucks of the traveling crane. The molds were placed in rows between the raised tracks, so when a bucket of concrete reached the mold for which it was designated, it was lifted from the truck by a traveling crane and its contents discharged into this mold. After the blocks had hardened for 24 hr. they were picked up by one of the traveling cranes and carried to an adjoining seasoning ground, where they were allowed to harden for 2 or 3 weeks before being built into the dam.


A Construction View near the Valve House.


A Typical Section of the Rock Foundation.

As the ordinary flow of the river is small in dry weather, during construction it was diverted at the site from its natural channel into a 12-ft. channel parallel with it. Before the masonry had been carried up high enough to close this diversion channel four 48-in. pipes were placed through the dam to carry the flow of the stream during the balance of the construction; two of these pipes were fitted with valves and are for permanent blow-off service, but the other two were provided for construction purposes only. The valves for the two permanent pipes were in a house on the downstream side of the dam, this house being covered with reinforced concrete to provide against damage by water overtopping the work during progress. The contracts provided that the valves should be left opened until the lowest portion of the wall reached a level of approximately 80 ft. above the river bed. Following an exceedingly dry period of 15 months' duration the flow in the stream became so small that one 48-in. pipe was more than sufficient to carry it. As the supply for the city was becoming badly depleted, an arrangement was made with the contractors to close the valves and impound such water as could be obtained. Immediately before this was done the lowest portion of the structure was 76 ft. above the bed of the river and the gap at that height was about 65 ft. in width. As a strange coincidence, within an hour after the valves were closed and following the 15 months of dry weather, a heavy rainfall began, with the result that a total rainfall of 10 in. occurred in the catchment area in the following 12 hr. This exceedingly heavy storm caused the water to rise and flow over the dam to a depth of 15 ft. in the gap, the reservoir above the completed portion of the dam holding at the time an estimated quantity of 2,000,000,000 gal. of water. In order to reduce the head against the dam one of the 48-in. valves was opened, but the other three could not be used because they had been set only a short time and it was not deemed advisable to risk the high velocity of the water passing through them. The rain ceased the following day, and within a very few days following the discharge from the open valve and that flowing over the uncompleted work reduced the level of the lake to the top of the masonry so the valve was partially closed and work resumed. No damage was done to the structure by this flood, although one or two of the large blocks of stone that had not been set were carried from the top of the uncompleted mass of masonry and struck on the roof of the valve house in falling.

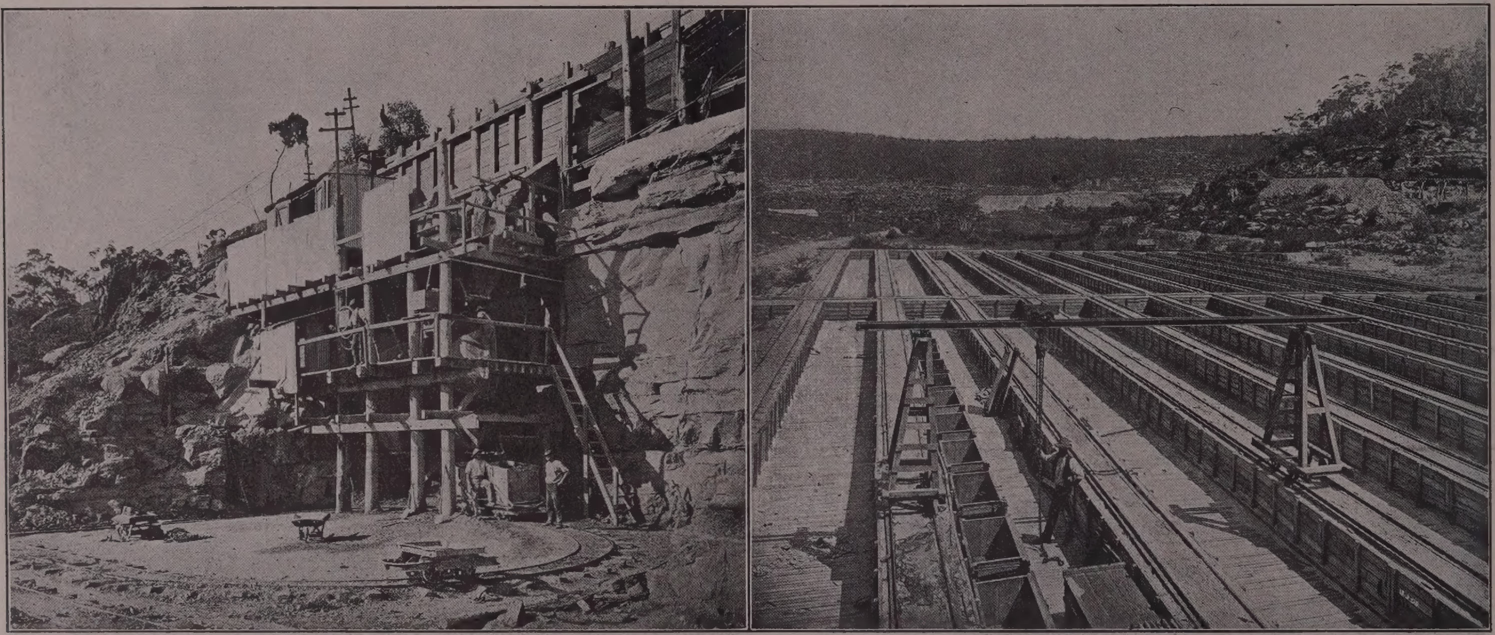
Blast holes for the rock excavation was in all cases made with Ingersoll-Sergeant compressed air drills. A compressor of the horizontal type driven by a portable steam engine supplied air to these drills.

A large portion of the contractor's plant was driven electrically with energy generated in a central station. This station contains two Cornish boilers generating 300 h.p. each and supplying steam to three electrical units. Each of these units consisted of a 65-kw. generator driven by a high-speed engine.

As the construction camp was unavoidably located within the catchment area of the Sydney water works, special precaution had to be taken to provide against surface pollution. The camp was divided into two sections, one for married and one for unmarried men. Large barrack buildings were erected for the latter and partially furnished, a charge being made by the Government for the accommodation; married men were required to erect their own dwellings under the supervision of the Government. The health and sanitation of the community was under the supervision of a resident medical officer.

The dam contains a total of about 146,000 cu. yd. of masonry of all kinds; 111,455 cu. yd. of Cyclopean masonry was used in the body of the dam; 1,975 cu. yd. of rubble masonry, and 8,996 cu. yd. of facing blocks; 19,000 tons of cement were required for various purposes. The total excavation included 215,000 cu. yd. of material, most of which was rock. The total cost of the entire work was approximately $1,665,000, which includes the following: Clearing, excavation, concrete, outlet work, 7 miles of highway leading to the site, the river diversion, valve house, sanitary, medical and insurance charges, supervision and contingencies. The construction plant used on the work cost $165,500, but only half of this sum was included in the total cost of the dam, because the other half can be charged to additional work on which the same plant can be used.

Mr. L. A. B. Wade, M. Inst. C. E., chief engineer for rivers, water supply and drainage, was in charge of the design and construction of the dam. This journal is indebted to Mr. Wade for the photographs and information from which this article has been prepared. Mr. E. M. de Burgh, M. Inst. C. E., of the same department, had principal charge of the construction; Mr. J. Symonds was resident engineer.



Concrete Mixing Plant and Concrete Block Yard at the Cataract Dam.

THE LATERAL THRUST OF WHEELS on rails has been investigated by the Schoen Steel Wheel Co. by means of a sensitive, self-recording apparatus. A 3-ft. rail section was used on the outer rail of a curve of 1,307-ft. radius. This piece of rail was held down firmly, but was free to slide outward slightly, pressing in the piston of a hydraulic cylinder in doing so. A small pipe connected this cylinder with a pressure gauge registering up to 200 lb. per square inch, a recording pressure gauge having the same maximum registration, and a pressure pump. The speed of the car was measured by a chronograph, the pen of which was momentarily lifted when the car passed by two trips or dogs a measured distance apart. The readings at medium speeds were erratic, but between 9.6 and 16.21 miles per hour the thrust of the wheel against the rail was very approximately equal to $333 V - 800$, V being the speed in miles per hour. This expression gives the lowest values. None of the speeds recorded was equal to that corresponding to the superelevation of the outside rail. The experiments indicated that a thrust against the rail amounting to nearly 21,000 lb. might be expected, and that the front wheel of the leading truck would probably exert the greatest thrust.

The Cost of Preventing Boiler Scale.

Some time ago Mr. Arthur D. Little, of Boston, was called upon by one of his clients controlling a considerable number of boiler plants, to study the conditions in them with a view to standardizing the methods of preventing boiler scale and reducing the expense of this work. Obviously his report cannot be made public in its complete form, but a general abstract follows.

In seven mills Mr. Little found soda ash and kerosene in use either alone or in combination with each other, while in three mills a sumac compound was employed. The price of the latter was 10 cents per pound, its approximate composition being: Water, 29 per cent.; insoluble matter, 9 per cent.; sodium carbonate, 43 per cent.; sodium phosphate, 13 per cent.; organic matter (tannin), 7 per cent.

Another mill was using a special compound costing only 2¾ cents per pound with an approximate composition of 14 per cent. of alkali, 5 per cent. of insoluble matter, and 81 per cent. of water and organic matter.

Still another mill was using a compound at 6 cents per pound composed of 10 per cent. of water, 53 per cent. of soda ash, 33 per cent. of common salt, and the remaining 4 per cent. of organic matter.

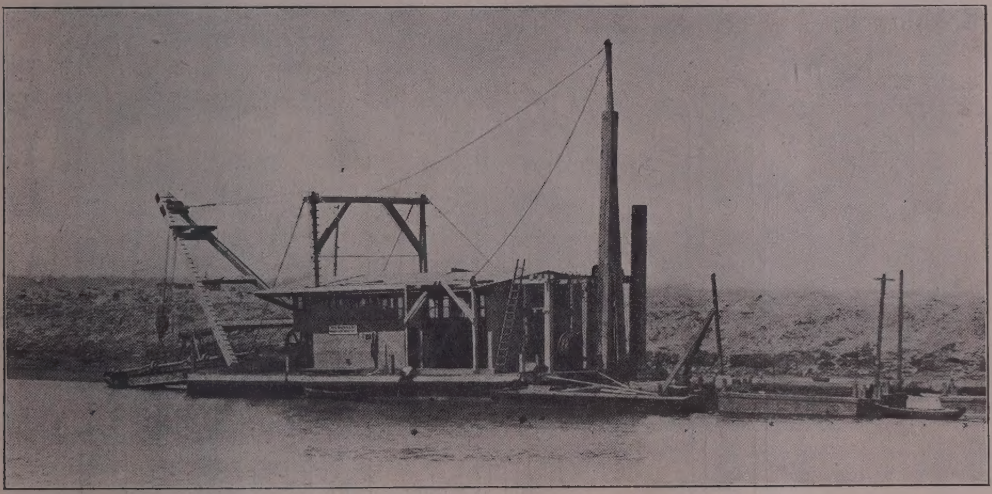
It was found that all the mills in the combination which used special compounds were expending nearly $1,300 per year for boiler compounds. Those which were using only soda ash and kerosene were expending very much less per horsepower although practically the same water supply was provided.

The method of applying the soda ash was investigated and it was found that in the case of a number of mills there was a mistaken idea of the use of a boiler compound. The methods employed in these, while differing somewhat in details, were to add the soda ash once a week and clean the boiler. The true method was shown to be to add the soda ash in small quantity continuously, and then keep the boiler in a condition so that by blowing off at frequent intervals it is kept clean.

It was shown by Mr. Little that a considerable saving could be made and a better result secured not only by reducing the cost of the compounds themselves, but by keeping the boilers in first-class condition and preventing the formation of scale, thereby reducing the amount of coal required to produce the amount of steam it is desired to carry.

An Electrically-Operated Dredge.

The port for the city of Los Angeles, California, will eventually consist of an extended series of slips and basins dredged from a salt marsh which extends along the shore line of the Pacific Ocean for several miles between the cities of San Pedro and Long Beach. This marsh is from 20 to 22 miles from the business portion of the city, but some of its lagoons reach to within 10 miles of the center. The Government is constructing an extensive breakwater to protect the western, or San Pedro entrance to the harbor; and also a number of outer harbor slips and the dredging of a portion of the marsh known as Wilmington Lagoon. This part of the work is being done with a 20-in. steam-driven dredge owned by the Government. Various minor slips to connect with this channel are being dredged by private interests and some of the municipalities fronting on the harbor lines. The harbor lines will doubtless soon be fully established by the Secretary of War, thus settling the areas to be dredged and those to be filled, so far as the limits of the tidal lands under the control of the Government are concerned.



View of the Electrically-Operated Dredge with Cutter Raised.

One of the channels running east will pass through the property of the San Pedro, Los Angeles & Salt Lake R. R. into that of the Los Angeles Dock & Terminal Co. at Long Beach. This connection is not, however, essential to that company as the property of the latter connects directly with the ocean through the old mouth of the San Gabriel River, known as Cerritos Slough. Across this channel a 168-ft. bascule bridge is now being erected by the railroad. At present this entrance will be less protected by the breakwater than that at San Pedro, but when warranted by the traffic the breakwater can be extended in the same depth of water far beyond Long Beach.

The Long Beach harbor is being constructed as a private enterprise by the Los Angeles Dock & Terminal Co., of Long Beach. This company expects to maintain in conjunction with the harbor a belt railway serving every slip and connecting with the three railways reaching the property, the Southern Pacific and the Pacific Electric in addition to the San Pedro, Los Angeles & Salt Lake.

The main entrance to the harbor will be 500 ft. wide at the jetties, which will extend into 50 ft. of water and be riprapped. It is anticipated that the tidal scour will be sufficient to keep this channel clear. Vessels will reach a large turning basin immediately after entering. This basin is 30 ft. deep and covers an area 900 x 1,600 ft. in dimensions. It will only be essential until the channel to the San Pedro basin is opened. Two channels, No. 1 and No. 3, start from this basin, while a third channel, No. 2, is a branch of No. 1. There will be extensive slips from channel No. 3. A shipbuilding plant, the first south of San Francisco, is already well advanced on this property, and is likely to be ready for business some time before the completion of the railroad bridge.

The excavation of the basin and channels and the reclamation of the swamp is being prosecuted with clam-shell and suction dredges. Most of the spoil is deposited on the undredged land to raise the general level 6 to 8 ft. About one-third of the total dredging, including all the embankments has been completed under contract by the North American Dredging Co. This company had a steam-driven clam-shell and an 18-in. electrically-driven suction dredge in the property for some years. The suction dredge had an 18-in. by 40-in. cast-iron unlined pump, driven by a 400-h.p. synchronous motor.

The Los Angeles Dock & Terminal Co. have now put in commission a 20-in. electrically-driven suction dredge which will be of interest for its method of drive. The use of electric power for dredging is a recent development, but it is held to offer many advantages which offset those of steam equipment for use on a vessel working in harbors and channels protected from the wind and seas. As power can be purchased at a very favorable figure in the region in which this dredge is operated, the dredge was equipped with an electrically operated suction pump and cutter wheel and also provided with a motor-driven winch for manoeuvring. A 35 x 71-ft. scow was used with an over-hanging A-frame at one end, from which the cutter ladder is suspended. The main pump is mounted crosswise of the vessel, the suction connection going forward to the ladder trunnion on the port side, while the cutter drive is on the opposite side.

A 20-in. cast-iron pump lined with boiler plate, which was designed by Mr. O. C. Goeriz, of San Francisco, and built in Los Angeles, is the main dredging unit. This pump has a cast-iron inclosed-type runner 68 in. in diameter, which is threaded on an 8-in. shaft and is held in place by a follower nut. The water passages are designed to handle, so nearly as possible, a constant quantity of water at any ordinary head, since the driving motor is of the synchronous type. The straightness of these passages leaves a triangular space between them which is connected to the back of the runner and so has dead water in it at all times. The runner is balanced against end thrust by concentric grooves which can be adjusted for leakage and the balance so kept perfect. No variation in the nature of the cut, length of line, height of bank or character of spoil has as yet been sufficient to affect very considerably the power required. There is sufficient clearance between the runner and the wearing nose where the volute comes closest to the runner to permit of filling a surface groove in the runner with 1-in. bars to produce a 70-in. runner if desired on long discharge lines. There would then be abundant clearance from the casing to permit fair-sized bodies caught in the runner to pass the nose without striking; and the runner passages will pass 8-in. stones.

The pump has two bearings, the outer one a five-ring babbitted thrust ring and steady bearing, while the inner is of the plain babbitted split-sleeve type. It is supported from the shell, but the upper half of the bearing shell can be stripped without disturbing the upper part of the pump shell or linings. The balancing ring is adjusted from the lower half bearing shell and is left in place when only the bearing is to be inspected. A water-packed groove supplied with clean water is provided at the end of the bearing to prevent excessive leakage of air and lubricating oil into the pump. This groove bears in a leather collar on the shaft and is thereby made to run with a nominal clearance. Both bearings can be adjusted for alignment in any direction.

The driven end of the shaft carries a 600-h.p. friction clutch, operated by a screw-controlled lever which can be advanced very slowly for slowly accelerating the pump runner and the body of water between it and the check valve and that beyond the valve, if the pump has not been standing so long as to let it waste out of the sleeves. The disk of this clutch is attached to a leather-link flexible coupling, which is mounted on the motor shaft. The pump and motor rest on a pair of 18-in. I-beams extending clear across the floor of the scow.

The pump is driven by a three-phase, 2,200-volt revolving-field synchronous motor of 675-h.p. continuous output capacity. This motor has two self-adjusting ring-oiling bearings with the shaft projecting at each end far enough to take the necessary couplings. The normal power consumption of the motor is, measured electrically, including motor losses, 530 h.p.

This type of motor must be started by bringing it up to synchronous speed before the motor is connected to the power transmission line, which is not the case with the induction type of motor; the low power factor at part loads and drop in speed with increasing load are serious disadvantages of the latter type for this service, and their small clearance would also be undesirable on craft where a good foundation is an impossibility. In this case, however, the use of a separate motor for starting only was avoided by arranging to start the pump motor from a 175-h.p. induction motor driving the cutter head. The starting shaft is arranged to be disconnected from the synchronous motor by opening a jaw clutch after synchronizing.

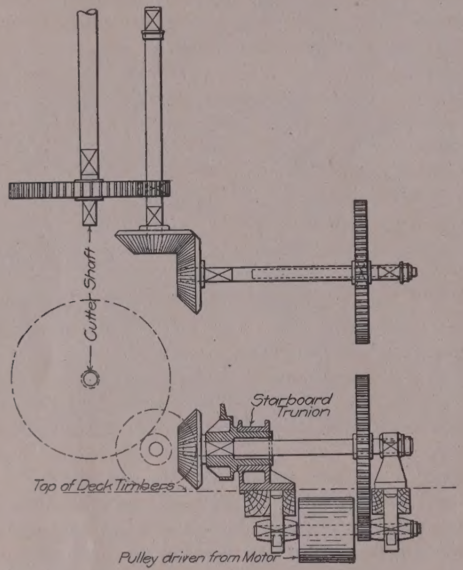
The electrical energy is brought aboard by means of armored three-phase cables or separate overhead lines. These lines are usually carried on the discharge pipe pontoons. There is usually an oil switch at either end of the floating section so as to cut out the wiring aboard the vessel or the entire equipment as may be desired. Upon entering the vessel the wiring runs to a distributing board equipped with oil switches having automatic trips with overload and manual trips under distant control. This latter arrangement permits the linesman to stop any portion of the machinery without leaving the levers.

The cutter-head motor drives a shaft which carries a friction pulley for the above purpose and another for the cutter drive. The cutter belt is on long centers permitting of some flexibility in the drive and so reducing the likelihood of accidents due to boulders and logs in the cutter. The cutter gear train reduces from 470 to 15 r.p.m., the counter shaft passing out-board through one of the trunnions. The main shaft is 8 in. in diameter, with flanged couplings. The boxes are split, babbited and fitted for both water and grease lubrication. There is a five-ring babbited thrust bearing near the after end of the shaft. The cutter head is a simple spider with flat blades, which seems to be satisfactory in the soft silt that is handled by the dredge.

The ladder is framed on two 50-ft. 20-in. I-beams, stiffened with numerous diagonals, with the forward bearing carried on the cast-iron nose piece and the intermediate ones on cast or structural bridges. The port trunnion carries the 20-in. suction pipe and the starboard trunnion the cutter drive. The trunnions are mounted on the main deck which brings all the mechanism out of the water when the ladder is raised. Repairs and adjustments can then be made in the minimum time. The rock box is also on deck, its cleanings being arranged to go overboard without handling.

Water for the various bearings, the water seals on the pump and for priming the pump is furnished at 25-lb. pressure by a 3-in. centrifugal pump, which is also sufficient for fire use. Priming and bilge pumping are done with water ejectors.

The scow is 8 x 35 x 71 ft. in outside dimensions and has 6 x 8-in. side and end timbers and 3-in. side plates. The hull is sheathed with 1-in. redwood on ship felt. The floor timbers are 12 x 12-in. pieces, extending the entire length of the vessel, while part of the deck timbers are 6 x 8-in. and part 12 x 12-in. Cross-wise of the hull are five stiffening frames. Four bulkheads, of which two run the entire length of the floor and two only part way, are provided. The main pump and its motor is set cross-wise of the hull back of the midship section; the I-beam frame on which they rest is on the 12 x 12-in. floor timbers. The deck beams are cut away at this point, leaving an open well. Side posts above this carry an I-beam trolley which extends over the side of the scow to pick up apparatus from the water.

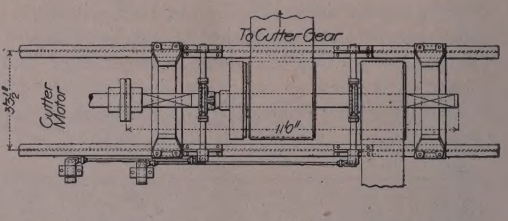


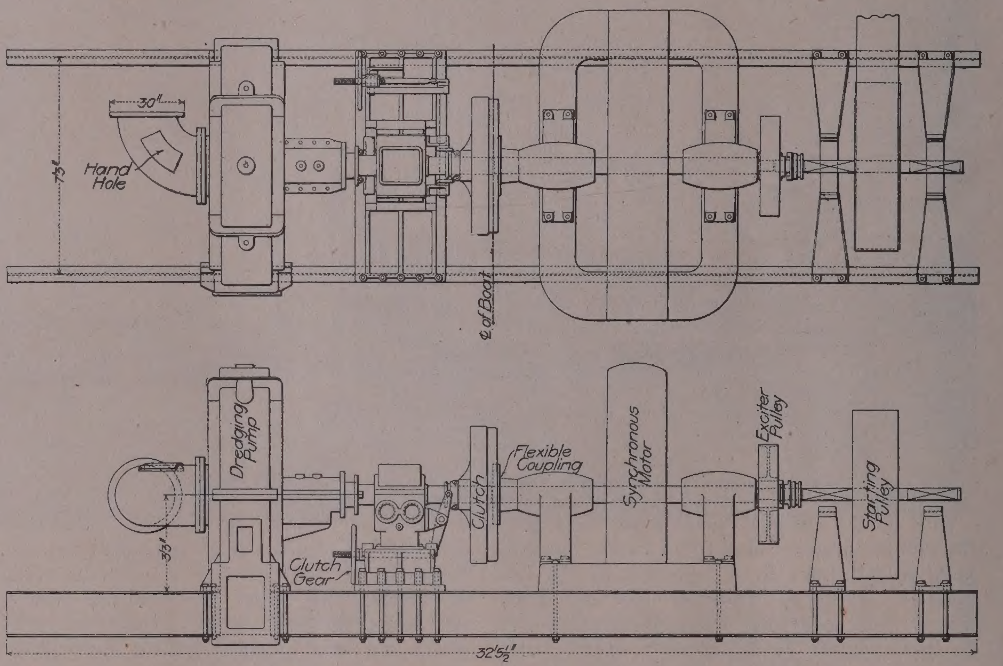
The Cutter Shaft Drive.

The dredger is equipped with a six-drum winch driven by a 52-h.p. variable-speed induction motor by which a 10,000-lb. pull can be put on any line at 40-ft. per minute. The side lines go ashore through guide sheaves on the forward end of the ladder frame. The spuds are 24 x 24-in. x 50-ft. Oregon pine cased in 1-in. wearing sheathing. The spud wells are of cast iron 28 x 28-in. in section. The lift line attaches near the bottom of the spud and leads over guide sheaves to a single multiplier. This lift line is 1 in. and all other lines ¾ in. in diameter.

The delivery pipe pontoons are mostly 16 x 8 ft. in plan by 4 ft. deep and are built of 2-in. plank, copper painted, but not sheathed. The pipe rests in saddles between bitts. The barge and ladder pipe, which is all of 20 in. inside diameter, is riveted pipe, built of ⅜-in. iron. The ells and fittings for these sections are of cast iron with clean out holes. The pontoon pipe is in 20 and 30-ft. lengths, with ends of ¼-in. plate, but 3/16-in. plate for the intermediate portions. This pipe is fitted with rubber connectors. The shore pipe is mostly No. 12 gauge drive-joint pipe with bands at the ends of the drive taper. The longest delivery line may not exceed 2,000 ft., while most of the spoil will be dropped less than 1,000 ft. from the boat. There is in service at San Pedro a line of stave pipe which is used by a private corporation to take the discharge from the government dredger and the long lines for this job may be made in the same manner if further use of this line proves satisfactory.

The dredge operates with no vibration and no noise. The only noticeable sound aboard the boat is due to the reduction gear train on the cutter drive, although a worm-gear drive could be substituted for this train and obviate the noise at the same economy, which would also tend to simplify the drive. The electrical machinery is compact and clean, requires little attendance and is very flexible. The cost of this equipment is also said to be considerably less than that of the corresponding steam equipment, while the fire hazard due to the lubricating oil and fuel oil or coal of the latter is very great, there having been three large dredges burnt in these harbors in the last five years.





Synchronous Motor Drive and its Starting Gear, Electrically-Operated Dredge.

If the winches are equipped with an auxiliary steam or gasoline engine for manœuvring when disconnected from the supply lines the boat can be better handled than can a steam vessel since the small engine can be started on short notice even if the rest of the vessel is out of commission.

The Los Angeles Dock & Terminal Company is a Long Beach company with Mr. C. J. Curtis, manager. The dredge was designed for them by Messrs. Pearson & Bennett, consulting engineers of Los Angeles, and this journal is indebted to Mr. Ralph Bennett, of that organization, for the detailed data on which this description has been based. The machinery was largely built in Los Angeles and was erected by the company.

The Cement Industry in this country in 1907 produced 48,785,390 bbl. of Portland cement, 2,887,700 bbl. of natural cement, and 557,252 bbl. of puzzolan cement, according to the U. S. Geological Survey. The total product is estimated to be worth $55,903,851, or about $600,000 more than that of 1906.

The Big Lazer Creek Bridge.

An excellent example of a single-track deck bridge of moderate span is afforded by the structure recently built at the Ambridge plant of the American Bridge Co. for the Atlantic, Birmingham & Atlantic R. R., Mr. Alexander Bonnyman, chief engineer. It is a deck structure with a 200-ft. channel span, flanked by two 90-ft. plate girder spans and is of standard construction throughout. The main span has pin-connected Pratt trusses 31½ ft. deep and 16 ft. apart on centers, and carries the track on two lines of plate-girder stringers, 7½ ft. apart and 25 ft. long, with their bottom flanges seated on the top flanges of the floor beams, which are riveted to the vertical posts just clear of the bottom flanges of the top chords. The end floor beams are made very deep and support on their top flanges the 90-ft approach girders, 7½ ft. deep in the lines of the main stringers.

The stringers and approach girders are braced in the usual manner with zig-zag angles and buck frames and the top chords of the main spans are X-braced with single lateral angles. The bottom lateral system consists of transverse struts and X-braces, made with single and double pairs of angles connected by vertical lattice bars with bent-plate connections to the lower chords. The end sway braces are made with pairs of angles latticed and the intermediate sway-bracing with single angles. The two end panels of bottom chords are riveted members and the vertical posts carrying the approach spans form parts of very rigid transverse bents with riveted connections to the inclined end-post and bottom-lateral struts making a solid, strong construction that is clearly shown in the accompanying illustration. The trusses have riveted pedestals with four bearings for the end lower chord pins, and are seated on I-beam grillages distributing their loads over the pier masonry. The end track stringers are rigidly connected to the approach girders and the shore ends of the latter have pin-connected shoes with roller bearings on the abutment seats.

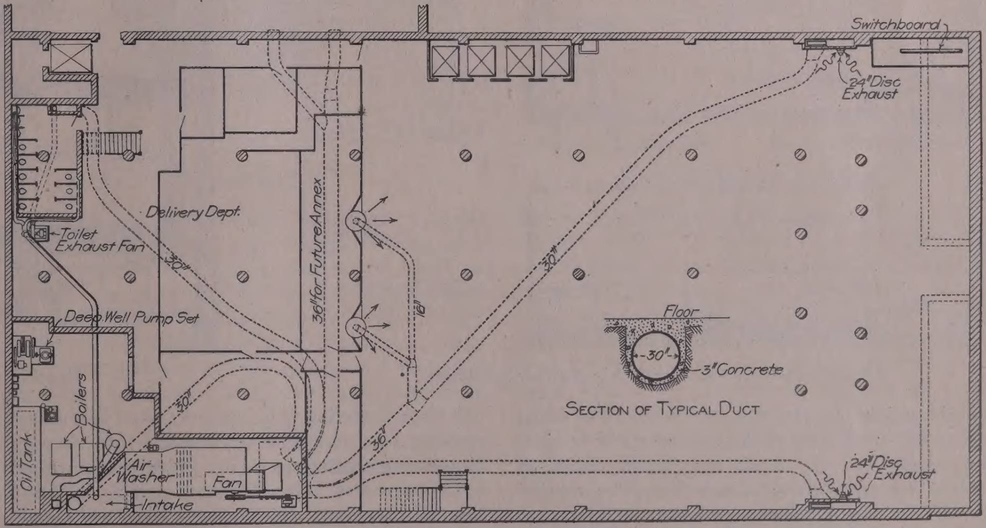
Heating and Ventilation of a Large Retail Store in San Francisco.

An interesting equipment of indirect heating has been installed in a large new store building recently erected at Market, Sixth and Stevenson Streets in San Francisco by Hale Bros., Inc., for their own occupancy. The structure, which is of fireproof construction, having full steel frame carrying brick walls, reinforced-concrete floor slabs and columns encased in reinforced concrete, is 98½ x 170 ft. in over-all dimensions and six stories in height above the street level, rising to a height of 110 ft. above basement floor level. It has a complete mechanical equipment, consisting of a freight and four passenger elevators, two package lifts, an automatic sprinkler system, vacuum-cleaning equipment, an artesian well-water supply and an equipment for the heating of the entire building by hot blast. There is, however, no power plant installed for the operation of the mechanical plant, the machinery of the building being electrically operated with current from the local supply company, while the steam supply for heating is furnished by a battery of low-pressure boilers.

Main Span and Support of Approach Span, Big Lazer Creek Bridge.

The heating is accomplished exclusively by hot blast on all floors, with the exception of the sixth, containing the offices of the store, in certain of which a limited amount of direct radiation has been added to supplement the indirect heating. The heating requirements imposed on the design of the system were, however, not severe, as the minimum daytime temperature in San Francisco is approximately 40° Fahr., and upon this basis the heating system was designed, heating surface being provided to maintain the store at 70° Fahr., with the outside temperature at the former figure. With this requirement it has been possible to adequately heat the building, with no more volume of air supply than is necessary for good ventilation, the blower equipment provided being capable of making, at full capacity, two changes of air per hour in the entire building. Features of the mechanical plant to be noted are the use of the air-washing system for the air entering the building and of an oil-firing system for the heating boilers.

The indirect-heating equipment is located in the basement at the rear and consists of a motor-driven centrifugal fan, a stack of heaters and air-washing apparatus, which, together with the boilers and artesian well pump, are located in a small irregularly shaped enclosure adjoining the delivery department. To this room the fresh air supply is brought down from the roof level in an intake that is unusual, as contrasted with the customary arrangement of intake at the sidewalk or street level in Eastern installations, relying on the air wash to purify the air supply. The supply is drawn from the roof through an intake shaft, which is 4 x 12 ft. in section, but contains two ducts for the delivery of air, so that the resultant velocity of intake is, at maximum capacity of the fan, about 800 ft. per minute. This intake opens at the basement into an intake chamber that connects directly with the air-washer casing.



Heating and Ventilating Equipment in Basement of the Hale Store Building.

The air washer is of the atomizing nozzle type, built by the Buffalo Forge Co., and is enclosed in a casing having a cross-sectional area of 70 sq. ft. and a length of 7 ft. The nozzles are 140 in number and are so arranged that they each deliver a cone-shaped spray of finely divided particles of water, with a pressure of 15 lb. on the pump discharge line. The chamber for the contact of air and water has a length of 5 ft., after passing which the air and suspended water encounter the eliminator plates, by which all particles of water and dirt in suspension are precipitated and drained to a tank located under the entire washer. The eliminator plates are arranged vertically and parallel to each other and are so designed that the air in its passage is deflected horizontally from side to side, the total eliminating surface being about 800 sq. ft.

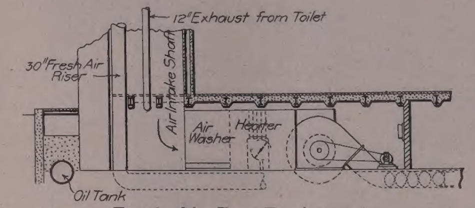
From the spray drip tank the water is drawn by a 1½-in. motor-driven centrifugal pump and again circulated through the spraying system, a fine-mesh screen being installed in the tank between the foot valve of the pump suction and the drain from the eliminator plates to prevent the passage of particles of dirt. The clogging of the atomizing nozzles is further guarded against by the installation of a basket strainer of fine wire-gauze in the pump discharge line. A by-pass from the pump discharge to the sewer, as well as a float control valve to govern the supply of fresh water to the tank, is provided, in order that the water may be renewed as frequently as may be desired. The centrifugal pump is direct connected to a motor, with a speed range of from 800 to 1,600 r.p.m., that is governed by a speed control rheostat, and has a special 8½-in. runner, the nominal running speed being at 1,300 r.p.m., with a power expenditure of 2¼ hp.

Next to the air washer are the heating coils, which are mounted on concrete piers, the bottom of the coils being located about 7 in. above the water line of the boilers, and are built upon 9-ft. cast iron bases, four in number. They are of the four-row, return-bend type, with a total height of 4 ft. 4 in., and are built up of 1-in. pipes, spaced 2⅝ in. on centers. The total lineal feet of pipe is 2,400, with free area for air passage of about 20 sq. ft., giving a velocity through the heater of 1,500 ft. per minute. The passage of air through or under the heater is controlled by louvre dampers for the former and a by-pass damper for the latter. Both the fan and heater were furnished by the Buffalo Forge Co.

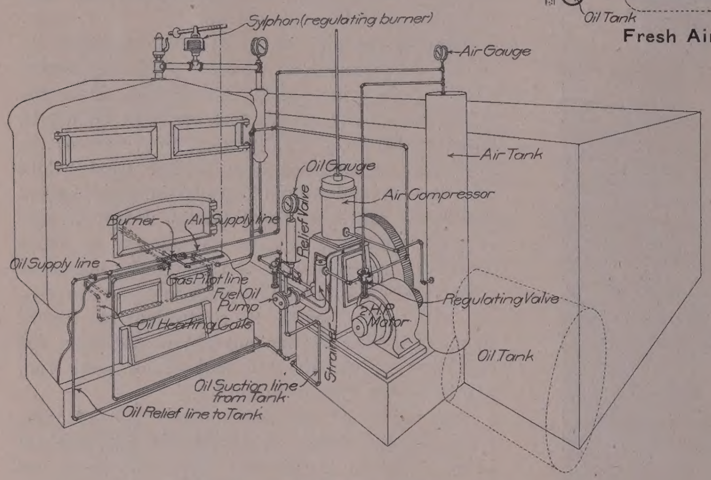
The fan is of the three-quarter housed type, with angular down discharge, the blast wheel being 7 ft. 8 in. in diameter and 3 ft. wide at the top. The fan is fitted for a speed range of from 130 to 300 r.p.m. and has an air capacity of from 25,000 to 35,000 cu. ft. of air per minute, with a normal working duty of 30,000 cu. ft., at 175 r.p.m., at which it requires approximately 10 hp. for driving. It is belt-driven by a 15-hp. motor, the speed of which is regulated by a speed control rheostat.

From the fan-delivery outlet the air is discharged into a concrete underground plenum chamber, from which it is carried to the four corners of the building in 30-in. galvanized-iron, concrete encased ducts, laid under the basement floor. These ducts are connected to vertical riser enclosures, which extend to the top of the building and have outlets at each floor, the size of pipe decreasing as the outlets are taken off. Each outlet is fitted with an adjustable damper, and the air enters the room through a diffuser, the construction of which is shown in an accompanying detail. The underground ducts were constructed by first placing a concrete bed in the bottom of the trench and forming the same so that it would conform to the contour of the bottom of the pipe; then placing the galvanized pipe thereon and using the side of the trench, which was of wet sand, as a backing and filling in with concrete and working same around the pipe and up to a level within 6 in. of the top of the pipe. To prevent distortion and collapse of the pipe, from the weight of cement on top, the side filling was allowed to set for some time before the top was applied. The average thickness of concrete about the pipe is from 3 in to 4 in.

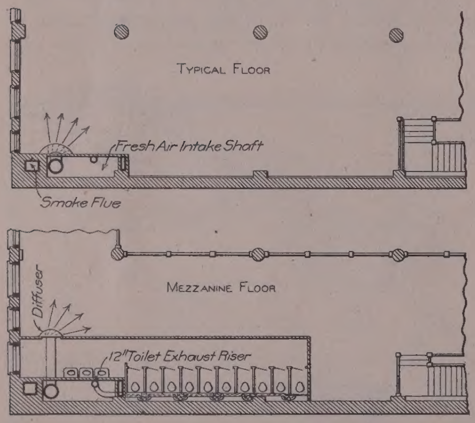
Tests have shown that this form of duct construction is quite satisfactory, giving, as it does, not only a smooth inside surface for the passage of the air, but the concrete serves to prevent excessive heat loss. The drop for the longest horizontal runs is 6° to 7° Fahr., which, taking into consideration the fact that the bottoms of these ducts are practically at the ground-water level at this point and the work new when tested, is within the range of good practice. The velocity of air in the underground ducts is figured at 1,600 ft. per minute, under full-load conditions, that in the vertical risers being gradually reduced from 1,600 to 1,000 ft. at the upper lengths. The air distribution from the plenum chamber is controlled by adjustable deflecting dampers at the point where the ducts enter the same, as shown in the basement plan drawing. A 36-in. duct is also provided for heating the annex to the building in the future, this being blanked off at present.



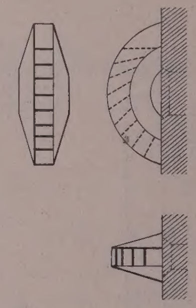
Fresh Air Fan Equipment.



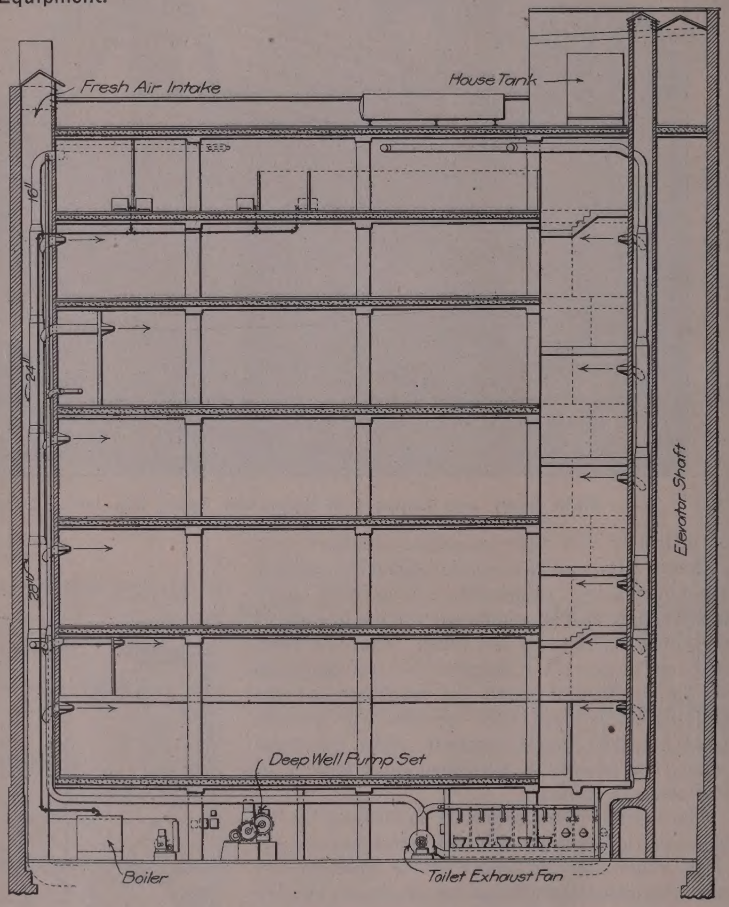
Fuel Oil Burning System.



Arrangement of the Fresh Air Delivery Outlets.



Details of Diffuser



Section of the Building Showing Air Ducts.

Steam for the heating coils is furnished by two cast-iron sectional American Radiator Co. low-pressure boilers, each having a capacity equivalent to 2,700 sq. ft. of direct radiation. These boilers are fitted to burn crude oil and have a burner control so arranged that the steam pressure is maintained constant by the automatic starting or stopping of the burner, the normal pressure carried being about 10 lb. The Glafke air-atomizing method of fuel oil burning is installed in this plant, air and oil being supplied to the burner at a pressure of from 15 to 20 lb., depending on the grade of oil in use. The entire oil burning set occupies a floor space of 30 x 36 in. and is set on a concrete foundation. The compressor is of the vertical one-cylinder, single-acting type, with a cylinder 6 in. in diameter by 6½ in. stroke, and is gear-driven at a normal speed of 130 r.p.m. by a 2-hp. motor. Upon an extension of the main crank shaft a ½-in. rotary force pump is located which supplies the oil to the burners, drawing the same from the oil tank.

Before entering the burner the oil passes through a gauze screen strainer and then through a pressure-regulating valve, which is controlled by the pressure in the air tank and so adjusted that in the event of the compressed air supply failing the oil supply will be cut off—this to prevent flooding the furnace with oil when there is no air available. Another regulating valve from the oil supply line is connected into a by-pass to tank, so that excess oil supply and pressure is cared for. The control of steam pressure is exercised by means of a "sylphon" diaphragm, built of thin sheet brass and in the form of a bellows, the raising and lowering of the top of which by the steam pressure actuates, by a system of levers, the oil and air supply to the burner. A pilot gas jet is constantly burned under the oil to ignite same after a period of shut-down.

The oil tank, which is a cylindrical tank of ¼-in. steel plate, is 3 ft. 6 in. in diameter by 20 ft. long, with the top slightly below the level of the grates of the boiler. This tank is surrounded by a 12-in. concrete wall and is covered to a depth of 4 ft. above the top with rock and concrete.

For exhaust ventilation of the store portion of the basement, the supply system is supplemented by two 24-in. motor-driven exhaust fans of the disc-wheel type, located as shown on the basement plan and discharging the air from the basement into flues extending to the roof, at the top of which louvre openings are provided.

For artificial ventilation of toilet rooms upon the first, mezzanine, fourth and sixth floors, and in the basement an exhaust system is installed, the fan of which is located in the basement, with galvanized-iron ducts, varying from 12 in. to 8 in. in diameter, run to the above toilet rooms. Back of each fixture and slightly above it is installed a 5-in. opening, protected by a wire-mesh screen. Branches from these openings connect into one line extending along and above the fixtures, this line in turn being connected to the main exhaust line. The fan is a cast-iron shell exhauster, direct connected to 3-h.p. motor having a speed range from 600 to 1,100 r.p.m. and a normal working speed of about 850 r.p.m., at which it uses about 1½ h.p., corresponding to a one-ounce air pressure. The fan has a blast wheel 24 in. in diameter by 6¾ in. wide at the tips and a 14-in. inlet.

For supply of water for the general uses of the building, as well as for the fire protection system, an artesian well was sunk to a depth of 194 ft. below the level of the basement floor, which well has a 16-in. outside casing for excluding surface water, and a 12-in. inside casing the entire length. To draw the water from the well and elevate it to the roof tank a 15-in. motor-driven Luitweiler pumphead is installed, having a maximum capacity of 100 gal. per minute, with a normal operating load of 50 gal. The speed of the motor governs this rate of supply, which is in turn regulated by a speed-control rheostat. In addition to this speed-control rheostat of the motor, the starting and stopping of pump is regulated by the Cutler-Hammer self-starting rheostat, operated by a float in the tank on the roof.

In order to provide a steady supply of water for fire protection, in the event of the failure of the supply of electricity, an auxiliary steam plant is installed, comprising an engine and boiler for the sole use of the pump. The engine, an 8 x 8-in. vertical, is connected to the pinion shaft of the pump by means of a jaw coupling, the arrangement being such that the motor can be backed out of gear and the jaw clutch thrown in. Steam for the engine is furnished by a vertical, high-pressure, submerged-head boiler, 42 in. in diameter by 8 ft. 6 in. high, and the piping system is so arranged that the steam from this boiler may also be turned into the heating system of the building if desired.

The mechanical equipment was designed by the architects of the building, Messrs. Reid Bros., of San Francisco, the mechanical engineering department of which is in charge of Mr. W. D. Edwards.

An Early American Cast-Iron Arch Bridge.

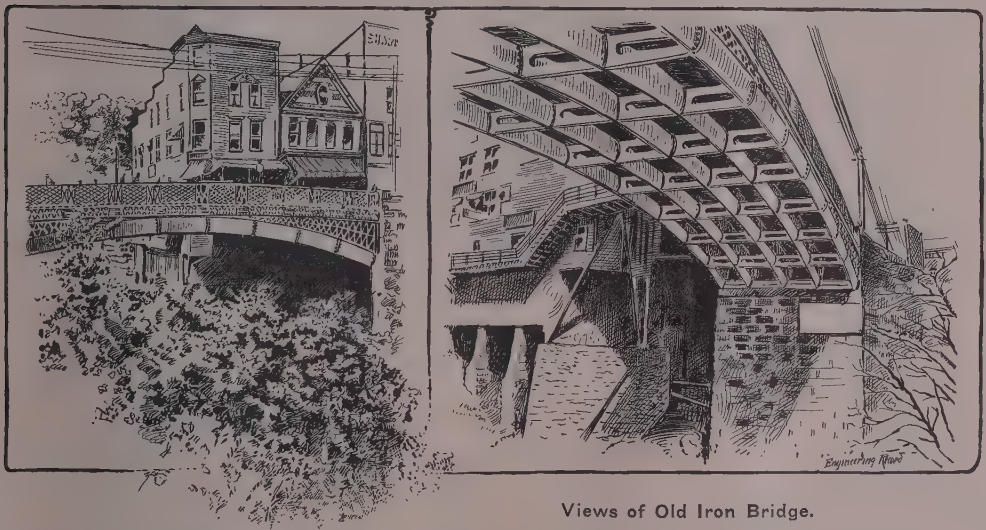
For many years the people of Brownsville, Pa., have taken pride in the sturdy fashion in which a cast-iron bridge constructed there about 1835 has been standing up under the traffic of three-quarters of a century. It crosses a small stream known as Dunlap Creek and carried the famous national pike which was built to connect the east and west sides of the Allegheny Mountains. Most of the bridges on this turnpike were masonry structures of excellent design, but the cast-iron structure shown in the accompanying sketches has a record of durability as good as that of the best of them.

The bridge has five tubular arch ribs of 85-ft. span and is 25 ft. wide. Each of the ribs is 10 in. wide and 30 in. deep, made up of flanged segments 3 in. thick, with eight 1½-in. bolts to each joint. The joints and flanges on each segment were chipped by hand, as the builders had no planer large enough to face them, and to ensure a uniform bearing on every joint a sheet of lead ⅛ in. thick was placed between each pair of flanges. This lead was cast in rough sheets and then hammered down to suit the conditions at each joint. After the bridge was finished and all the joints screwed up tight some of the lead was squeezed out in the final settling to a permanent bearing of all parts of the structure.

The ribs carry panels which support a deck of cast-iron plates covered with a macadam roadway. On each side of this roadway there is a latticework of 1 x ¼-in. wrought iron bars surmounted by a cast-iron 2 x 3½-in. handrail recessed at the bottom to receive the lattice-bars. These bars rusted out in places about thirty years ago and were then patched, but otherwise the bridge has not been repaired since its erection.

The bridge was built by John Snowdon, of Brownsville, from the designs and under the direction of his foreman, John Herbertson. The latter's career was characteristic of that of many of the pioneer mechanics of his time. He was born in Glasgow in 1805 and received a good common school education, together with some instruction in scientific subjects through attendance at lectures by well-known professors of that city. He learned the trade of joiner and cabinet-maker and came to America when he was about 17 or 18 years old. A notorious impostor had been working in Glasgow and its vicinity to induce people to emigrate to Marietta, Ohio, and young Herbertson went there directly, but acquired nothing but fever and ague in the place. In April, 1824, he moved to Pittsburg and lived there for five years, engaged for most of the time in the pioneer steam engine shops of that city. In 1829 he went to Brownsville as foreman of the engine shops of John Snowdon, and while engaged there designed the bridge just described. His drawings of the structure were sent to the U. S. Military Academy and were approved by officers stationed there, but they have been lost. The pattern making, molding and erection of the bridge were all done under his supervision. About 1838 he formed a partnership with Thomas Faull to carry on a general engine-building and machinist's business, and a few years later purchased his partner's interest. He remained actively interested in this work until his death in 1890, and built many steamboat engines as well as engines for mills, which were shipped to many states and to Mexico. His business has been continued by his sons, and to one of them, Mr. W. H. Herbertson, this journal is indebted for these notes.

The accompanying sketches have been drawn from photographs of the bridge taken at different times during the last dozen years. The structure was much more attractive years ago than it is now, for of late the upper parts of the wing walls have been torn away and buildings have been erected on them which detract from the general appearance of the bridge.

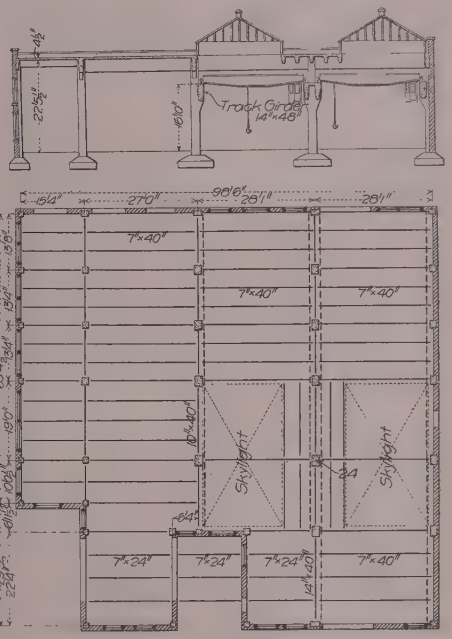


Views of Old Iron Bridge.

The Marble Finishing Building of Maltby & Sons, Buffalo, N. Y.

The marble and granite finishing shop of Maltby & Sons, Buffalo, N. Y., is a reinforced concrete building, with some especially interesting points in the design of crane girders and bracketed columns for supporting them. The building has another point of interest in that it is designed for three stories, though but one story has at present been erected. The slab which now forms the roof will eventually be the floor of the second story, and therefore instead of being calculated for a comparatively light roof load, has been given the strength required for carrying the machinery which is to be installed when the building is completed. This demanded an allowance of 300 lb. per square foot. Two skylights of large size are built over portions of the bays occupied by the large crane, and this naturally necessitated a special system of framing, since the skylights do not occupy the full width of the bays. Reinforced concrete is used for the floors and the skeleton frame of the building, the exterior walls being carried up in brick and faced with stone taken from the company's own stock.

The building is 100 ft. square in plan and is divided longitudinally into three wide bays, two of them 28 ft. 1 in. between centers of columns and the other 27 ft. The remaining bay is 15 ft. 4 in. wide. The spacing of the columns in the other direction is variable, although there are a number of 13 ft. 4-in. spans. The longest span is 19 ft. Two of the adjacent wide bays are provided with 25-ton cranes for transferring slabs and blocks of stone from one machine to the other in the process of finishing. The crane span is about 25 ft.



Marble Finishing Building.

The crane rails are carried on reinforced concrete girders, 14 in. wide at the top, 10 in. wide at the bottom and 4 ft. deep, reinforced with "Pin-Connected" girder frames. This connection results in transmitting a portion of the strain, when the crane is in a given span, to the girders of adjacent spans. The maximum span of the crane girders between centers of columns is 22 ft. 4 in. The girders are carried upon the main columns of the building by means of concrete brackets, reinforced with cold twisted lug bars. The method of placing these bracket bars is shown in an accompanying illustration. They are of ¾-in. steel, three being used in each bracket. Ties of ¼-in. lug bars are run back from the bracket steel and imbedded in the body of the main column. Additional reinforcement is put in the top element of the crane girders in the shape of sheets of expanded metal.

On account of the cranes being placed in adjacent bays, one line of columns has brackets and girders on both sides. Advantage is taken of this fact to secure additional transverse support for the girders carried by this line of columns by tying them across with a slab of concrete, which is reinforced with lug bars and expanded metal. The distance center to center of these parallel adjacent girders is 34 in.

On account of irregularity in the spans of the building and the placing of the cranes and skylights, the dimensions and details of the columns are quite irregular. Those columns which carry the crane girders are uniformly increased in section below the level of the latter, though the only change in the column reinforcement consists, through the distance occupied by the brackets, in additional ties and the bracket rods. The smallest columns, those in the exterior walls in the narrowest bay, are 14 x 16 in., reinforced with four ¾-in. bars, placed as a square and tied together by ¼-in. ties of cold-twisted lug bars spaced on 1-ft. centers. Where the columns carry a crane on one side only they measure 20 x 20 in. above the girders and imbed eight ⅞-in. bars, bound with ¼-in. ties. This reinforcement continues down through the lower part of the column, but the longitudinal rods are spread apart, and the dimensions of the columns are increased to 22 x 26 in., the longer dimension being parallel to the direction of the crane run. The largest columns, those supporting a crane rail on each side, are 20 x 20 in. above the rail and 22 x 30 in. below. The reinforcement here, consisting of eight 1-in. bars, with ties as above described, Column 24, shown in the plan between the skylights and carrying crane girders on each side, though of the same dimensions as the columns just described, is reinforced with ten instead of eight 1-in. bars.

Unlike the dimensions of the columns, the girders are quite uniform throughout in section and are designed, as noted above, to carry a floor figured for loads of 300 lb. per square foot. Beams having a span of less than 20 ft. between centers of bearing are 7 in. wide and 24 in. deep, the latter dimension including the 4½-in. reinforced concrete floor slab. Beams over 20 ft. span, the maximum of which are 28 ft. 1 in. between centers of columns, have the same width as the other beams, but are increased in depth to 40 in. Most of the girders are 10 in. wide and 40 in. deep, and some of them are made to carry the loads transferred to them by three beams of 27-ft. span, spaced at the quarter point. The beams and the girders in the outside walls are not provided with knee braces, while the interior girders have such a brace, 2 ft. deep, sloped 45 deg. and reinforced with ⅝-in. lug bars.

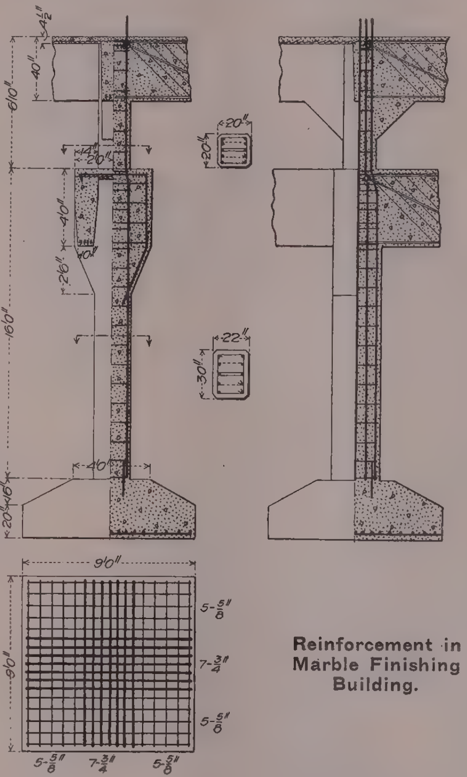
The floor slab for carrying the load of 300 lb. per square foot is 4½ in. thick and reinforced with expanded metal. Care was taken in all of the work to place 2 in. of concrete around all steel so as to protect it adequately from fire.

The columns rest on reinforced concrete footings varying in plan dimensions according to the load to be distributed. The steel is placed in a right-angled grid. The details and reinforcement of these footings are shown in an accompanying illustration. Twenty-three tons of cold-twisted lug bars were used in the footings and the columns and 1,600 lb. of expanded metal in the slab reinforcement.

The General Fireproofing Co., Youngstown, O., designed and fabricated the steel reinforcement. The "Pin-Connected" girder frames used in all lintels, crane girders, floor beams and girders and the column reinforcement were built in Youngstown and shipped to the work ready to be put in place. The general contractor was the Buffalo Expanded Metal Co., Buffalo, N. Y., and Green & Wicks, also of Buffalo, were the architects.

The Clogging and Cleaning of Water Mains.

The advisability of inserting special castings to facilitate the cleaning of water mains which are intended to carry water liable to tuberculate or otherwise clog the pipes was discussed in a paper by Dr. George F. Whitney presented at the recent convention of the American Water Works Association. He advocated the insertion of hatch boxes at intervals of about 1,000 ft., not only because such fittings would materially decrease the cost of future cleaning, and by their constant availability serve as an incentive to clean the pipes before the loss of head became abnormal, but also because of the great saving in time, thereby lessening the inconvenience due to the cleaning operations and the possible suspension of fire-protection service. Where the pipe must be broken and a special fitting put in, the minimum time for shutting off the water for cleaning purposes was stated by Dr. Whitney to be 4 hr., while with the special fittings installed in the line, the time is reduced to about 45 min. for every 1,000 ft., this being the period required for the actual cleaning. If the water mains were regularly cleaned and kept free from any roughness, the saving in fuel, Dr. Whitney stated, would probably be sufficient to pay for all cleaning. Since cleaning would then be relatively cheap, its cost could be added to the cost of maintenance, and the letting of separate cleaning contracts avoided.



Reinforcement in Marble Finishing Building.

Some new aspects of the clogging and cleaning problems were presented at a discussion of this paper in a written communication from Mr. Alexander Potter, in which the following were the principal points brought out:

Not only is it necessary to deal with the tubercules composed largely of vegetable deposit which produces carbonic acid, that in turn attacks the iron mains, but as the art of water softening is extended, a new probable cause of pipe coating is introduced. With a tuberculated pipe, the softening of water will have a tendency to reduce gradually the thickness of the deposit on the pipes; in fact, the softening plants will come in for a great deal of criticism, as these old deposits are carried forward in the mains and drawn off in the taps. Of course, the softening plant will be held responsible, and the real benefits of the plant in producing better water for all domestic and culinary purposes will be forgotten. Theoretically, the proper softening of water should have no effect upon the walls of the pipe if the process of softening is extended to include the re-carbonating of the water, provided excessive re-carbonation is avoided, and all the steps of the water-softening process are carried out as planned, but unless the softening plant is properly designed and built of proper capacity to handle all the water, and unless the fluctuations in the character of the water are met by the proper means and kinds of chemicals, after-reaction is bound to occur which will throw down a precipitate on or from the walls of the mains. The experiences at Quincy, Ill. [described in The Engineering Record of May 16, 1908], are "horrible examples" of what may occur when reactions are allowed to take place in closed pipes.

The largest part of the cost of cleaning water mains is in the preparation of the main for the insertion and removal of the cleaning apparatus. Not only should the pipe system be provided with permanent hatch boxes for the inspection of the pipe and the insertion of the scrapers, but the alignment of pipe systems should be arranged to permit of as long scraper runs as possible. It is of the utmost importance, Mr. Potter stated, that a tuberculated pipe be cleaned before the tubercules attain any great size. Tubercules are not deposited with any degree of uniformity over the surface of the pipe; in fact, in many cases they are deposited in a very irregular manner. Therefore, the jar or shock of the cutters on the scraper in passing from a heavily to a lightly tuberculated portion of the pipe, or over large isolated tubercules, is liable to rupture the coating on the pipe and make the further process of tuberculation more simple.

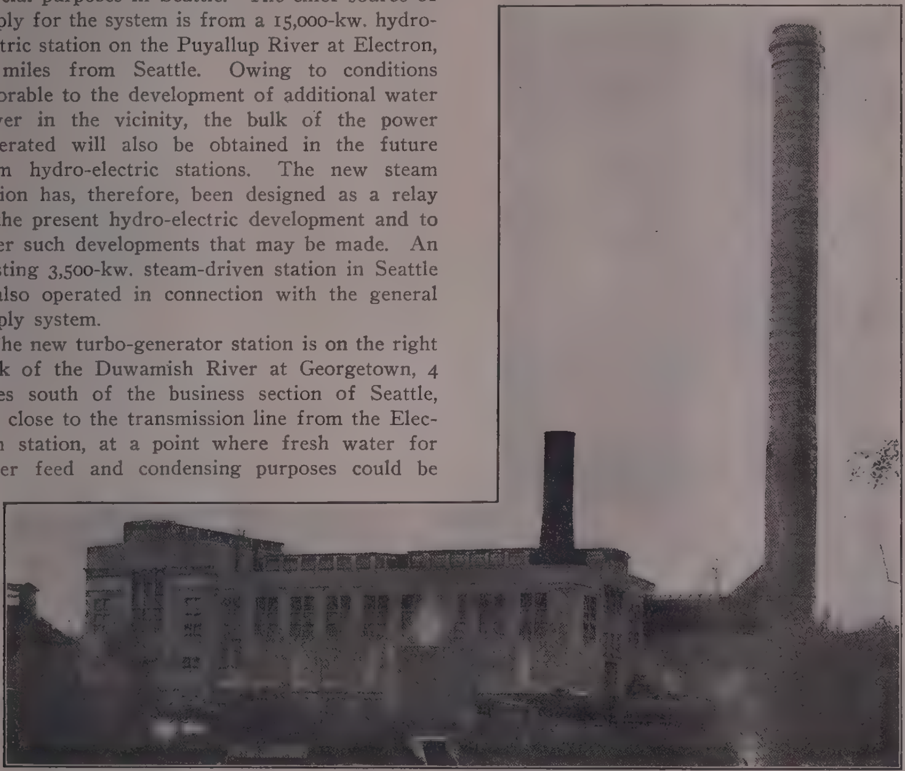
In connection with the cost of cleaning water mains in the past, Mr. Potter called attention to the following statement by Mr. H. W. Johnston, assistant city engineer of Halifax, Nova Scotia: "The average cost of cleaning the 24-in. low service main for the past 20 years has been $15.07 for each cleaning of 13,400 ft., and of cleaning the 15-in. high service main $18.80 for each cleaning of 36,340 ft. Between 1882 and 1904, both inclusive, there has been cleaned 223 miles of mains at a total cost of $732.07, or at an average rate of $3.28 per mile." These figures seem so extraordinarily low that doubt will arise whether or not the pipes actually require cleaning at all. However, Mr. Potter stated that some 15-in. pipes were reduced to 12 in. and some smaller mains have been practically choked. Halifax water is an unusually soft water, but has constituents which seem to have a great affinity for iron.

The important phase of the cleaning question is the extent to which the removal of tubercules on the pipes affects the thickness of the walls of the pipe. An analysis of one sample of deposit taken from a tuberculated system showed that one-eighth of the entire volume was iron. As an analysis of the water supply itself indicated the absence of iron, the iron in this sample must have come from the water main. Where this tubercular action is constantly going on, the extent to which it destroys the walls of the pipe is important to know. It is hardly conceivable that the iron in these tubercules is drawn uniformly from around the perimeter of the pipe. It is more than likely that the pipe is attacked in spots; consequently, the extent of the corrosion on the pipe wall is greater at one point than another, and it is conceivable that in time this action will be so great as to pit the walls of the pipe to such an extent as to produce considerable leakage. Mr. Potter is of the opinion that an inquiry as to the relation, if any, that the scraping of the mains has to the leakage in the pipe system is worthy of consideration.

An 11,000-kw. Turbo-Generator Station in Seattle, Wash.

An 11,000-kw. turbo-generator station has recently been placed in service in connection with the general power-supply system of the Stone & Webster interests in Seattle, Wash., and vicinity. Power is delivered from this system to operate the street railways, and for lighting and commercial purposes in Seattle. The chief source of supply for the system is from a 15,000-kw. hydro-electric station on the Puyallup River at Electron, 60 miles from Seattle. Owing to conditions favorable to the development of additional water power in the vicinity, the bulk of the power generated will also be obtained in the future from hydro-electric stations. The new steam station has, therefore, been designed as a relay to the present hydro-electric development and to other such developments that may be made. An existing 3,500-kw. steam-driven station in Seattle is also operated in connection with the general supply system.

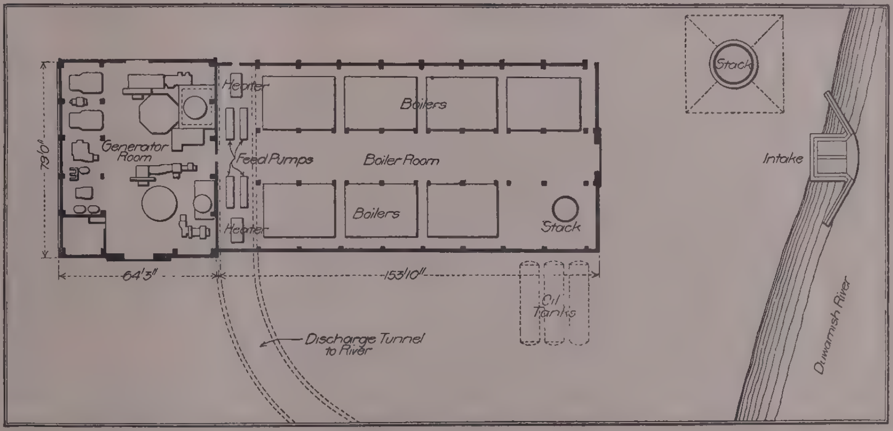
The new turbo-generator station is on the right bank of the Duwamish River at Georgetown, 4 miles south of the business section of Seattle, and close to the transmission line from the Electron station, at a point where fresh water for boiler feed and condensing purposes could be obtained. The present station is the first one of six sections which it is proposed to build in conjunction therewith on the same site. This first section is entirely independent of the future additions, however, although the arrangement of its generator room is such that the latter will become a part of one main generator room as the other sections are built.



The First Section of the Station Building.

The station building is a reinforced-concrete structure, 80 x 218 ft. in plan, and with a height of 68.25 ft. from the ground line to the top of the roof. The reinforced-concrete frame, and the side and end walls of the building, stand on spread footings of concrete carried by piles driven to refusal, 1,800 piles being used to secure a stable foundation for the building and equipment. The side walls of the building are 10-in. reinforced-concrete slabs carried by columns spaced 16 ft. apart on centers; the end walls are 6 in. thick and are carried by columns spaced 15 ft. 1 in. apart on centers. The roof consists of 5-in. reinforced-concrete slabs carried by beams and girders resting on the wall columns and on rows of columns in the interior of the building.

The building is divided by a transverse 6-in. reinforced-concrete wall into a boiler room and a generator room, the former being 153 ft. 10 in. long, and the latter occupying the remainder of the building. A basement, with its floor at the ground level, extends under the entire boiler room. The boilers are on a reinforced-concrete floor over this basement, which floor is carried by reinforced-concrete columns on spread footings on piles. The level of this floor is 15 ft. above the level of the basement floor, thus providing abundant space in the basement for handling ashes from the boilers and for other purposes. The boilers are placed in two longitudinal rows, one on each side of a firing room. Reinforced-concrete coal bunkers are placed over this floor, with a monitor in the roof over the bunkers, which provides space for coal-conveying apparatus. The floor of the generator room is level with that of the basement under the boiler room. The roof of the generator room is carried by 65-ft. span reinforced-concrete girders, extending from the transverse partition wall to the end wall of the building, so this room is entirely free of columns. The switchboard, wiring connections, switches, transformers and electric auxiliaries are at the opposite side of the generator room from the boilers, in a reinforced-concrete gallery having four floors above the generator room floor.



Plan of First Section of the Station Building.

The original plans for this first building section of the station contemplated that two turbo-generator units, one of 3,000-kw. and one of 5,000-kw. capacity, would be installed. Soon after the smaller unit had been erected, however, the decision was made to install a unit of 8,000-kw. capacity instead of the proposed 5,000-kw. one, on account of increased demands on the system for power. Otherwise, the arrangement of the station was carried out as originally proposed. According to this original arrangement the two units are placed at the same floor level, with one unit on each side of the longitudinal center line of the building. Steam to operate each unit is normally supplied by the row of boilers on the corresponding side of the boiler room, although either unit can be supplied from either side.

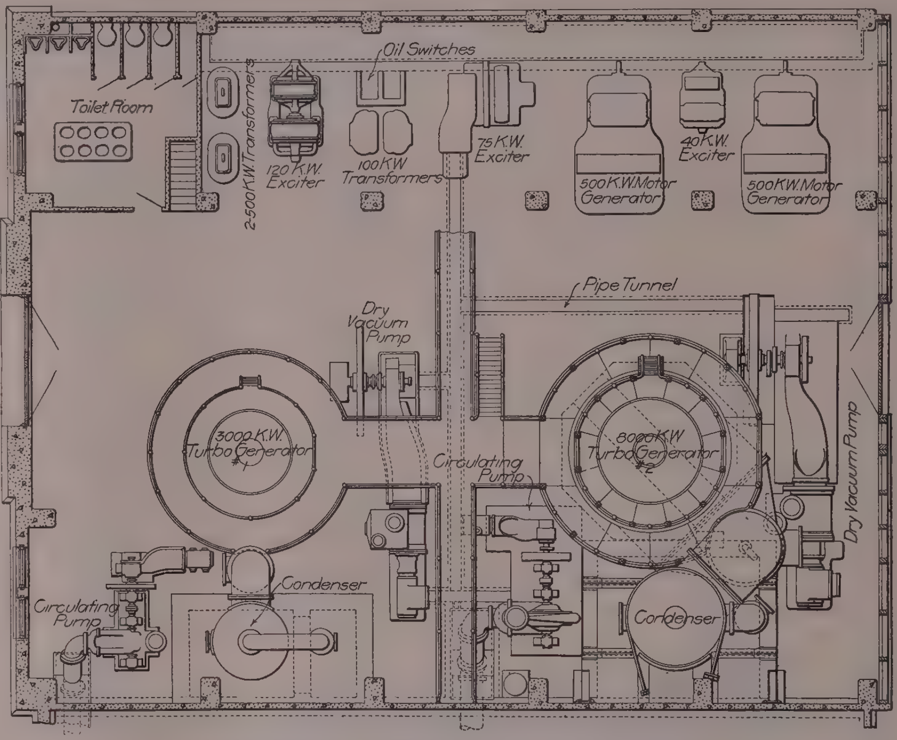
The boiler room contains fourteen 466-h.-p. Stirling water-tube boilers, set in batteries of two boilers, with three batteries in a row on the 3,000-kw. turbine side, and four batteries in a row on the 8,000-kw. turbine side of the longitudinal firing room floor. These boilers are at present fired with fuel oil. Since oil may eventually be superseded as fuel by coal, the storage bunkers for the latter were built over the firing floor and the provisions made in the construction of the building to permit coal-conveying apparatus to be installed. Reinforced-concrete ash storage hoppers were also built, suspended in the basement of the boiler room from the floor of the latter, one hopper under the furnaces of each boiler. These hoppers are placed at a height that permits cars to be operated under them on tracks in the floor of the basement. Since coal will probably not be used for fuel for some time, none of the mechanical equipment to handle it has been installed.

A very complete storage and delivery system has been provided to handle the fuel-oil supply. The oil is delivered in tank cars on a switch extending around the downstream corner of the end of the boiler room next to the river. Three 8 x 32-ft. circular steel tanks are placed side by side in the same horizontal plane under this track, where oil can be delivered directly into them from the tank cars. A single-acting reciprocating oil pump in a house at one side of this track is also arranged to take oil from the tank cars through a 5-in. flexible suction hose and deliver it through a 6-in. connection to a 150,000-gal. steel storage tank, 30 ft. in diameter and 30 ft. high. This tank is placed with its center 83.5 ft. from the adjacent corner of the building, and is surrounded by a pit large enough to hold the contents of the tank in case the latter should break. The exhaust from the oil pump is connected to a steam coil in the bottom of the oil tank in order to supply the heat necessary at times to thin the oil so it will flow readily. A live-steam pipe is also connected to this coil as an auxiliary.

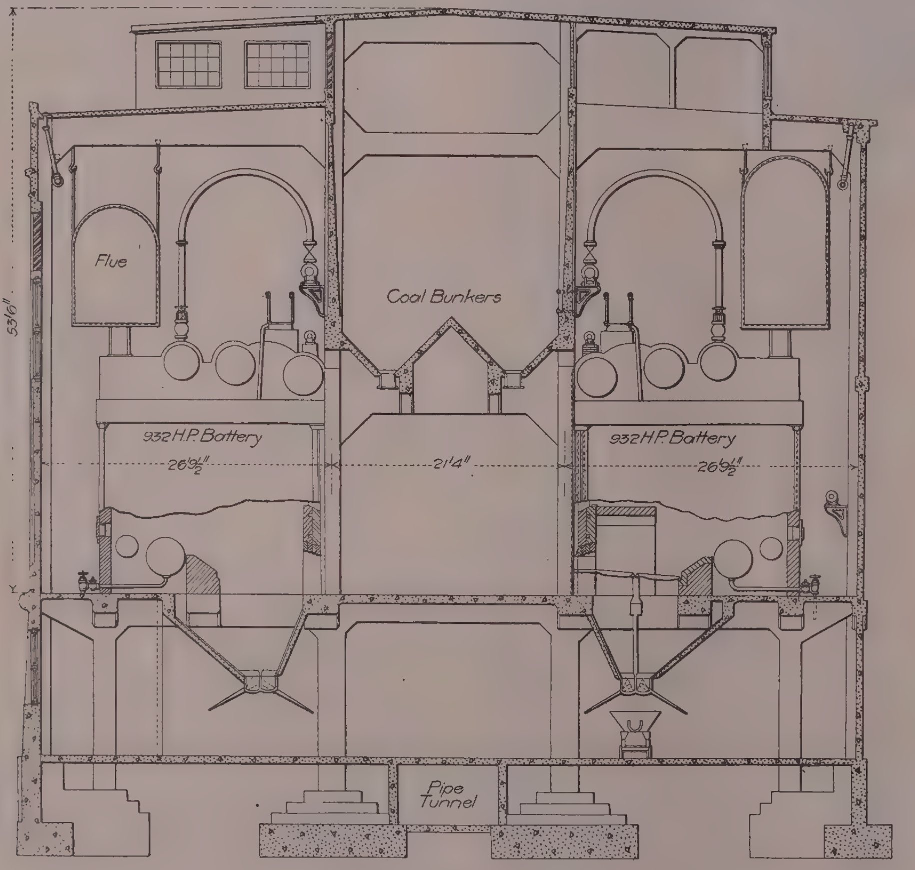
The suction and discharge connections of the oil pump are joined with a by-pass. This by-pass and the suction and discharge connections are fitted with valves that enable the pump to be used in various ways. The oil can be taken from tank cars through the 5-in. flexible suction hose, and delivered to the large storage tank through a 6-in. connection, or from that tank to the cars. Oil in the large tank will flow by gravity into the three underground tanks through the same 6-in. pipe to which the discharge of the pump is connected, until the level in the large tank is reduced nearly to the bottom of the latter; after that the pump can be used to deliver the oil below that level. The pump can also deliver the oil from the tank cars directly to the underground steel tanks.

The three underground steel tanks are each fitted with a live steam coil for heating the oil, these coils draining to the river. The 6-in. pipe into which the discharge and suction of the pump are both connected, and through which oil is supplied to, or drawn from the large storage tank, passes around in front of the three small ones and thence into the station building. In the building this pipe is connected to a header from which two 10 x 6 x 16-in. Wagener steam-driven oil pumps are supplied. These pumps are arranged together in a pair, with two 2 x 7-ft. circular oil heaters between them. Each tank is supplied with exhaust steam for heating and is operated the same as a closed feed-water heater. Each tank contains 87 ft. of 2-in. pipe through which the oil is pumped under a pressure of about 40 lb., maintained by an automatic pump governor. After passing the heaters the oil is delivered through filters to the burners under the boilers. Instead of an intermediate pressure tank being placed in this supply system, the discharge connection of each pump is fitted with a relief valve, the discharge from which is carried back to one of the underground tanks by an overflow pipe.

A 2½-in. oil supply line is carried from the pumps along in front of both rows of boilers. This line is paralleled by a 2-in. pipe connected to the superheated steam main and also to a saturated steam main. At each boiler a connection is made to both supply pipes to deliver steam and oil to the burners under the boilers. The boilers are of the standard Stirling water-tube type, with superheaters located in the rear pass behind the steam-generating portion of the boiler. Each boiler is provided with one mud drum and two steam and water drums, which are connected together with inclined tubes. The superheater consists of an upper and a lower drum connected together by vertical tubes. Steam is delivered from the rear steam drum of the boiler to the upper superheater drum, and thence passes through alternate downward and upward sets of tubes before being delivered to the piping system.



Arrangement of Equipment in Generator Room.



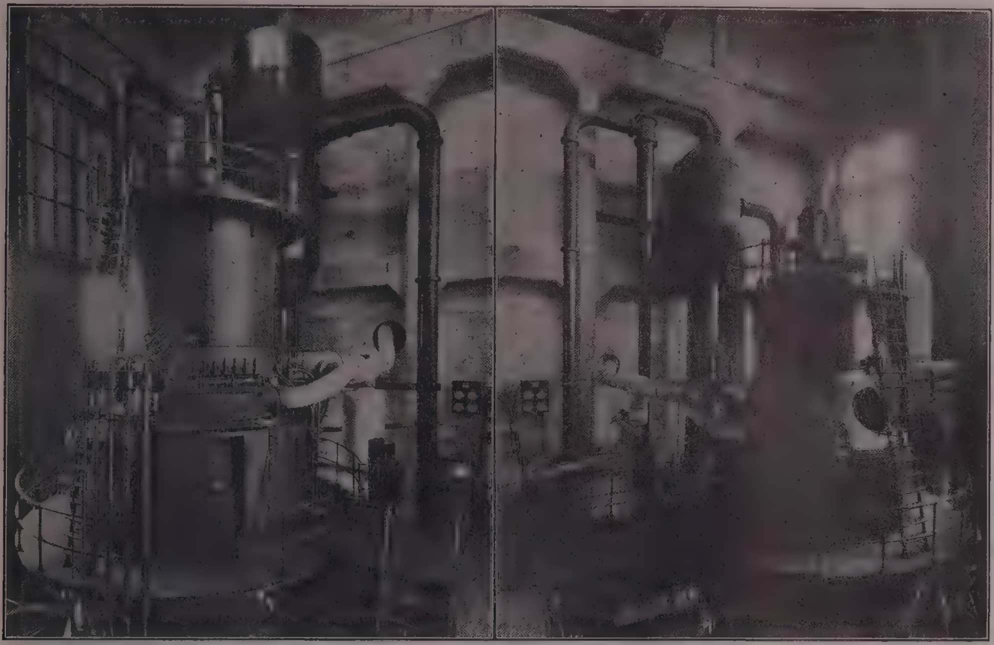
Cross-Sectional Elevation of Boiler Room.

The row of three pairs of boilers for the 3,000-kw. unit is arranged to be served by a Green mechanical-draft installation when coal is used as fuel. The breechings from the boilers connect with a flue leading to a steel stack, 11 ft. in diameter and 125 ft. high above the grate, which stack is suspended by a system of concrete girders that are carried by the frame of the building. A 15 x 7.5-ft. Green induced-draft fan, belt-driven by an 85-h.-p. General Electric motor, will furnish draft for this system.

The breeching from the boilers of the row on the opposite side of the room are connected by vertical uptakes to a steel-plate flue leading out of the building to a reinforced-concrete stack. The cross-section of this flue connection is uniformly increased from the first pair of boilers to beyond the last pair, where it is 7.5 ft. wide by 15 ft. high. The reinforced-concrete stack, which was built by the Weber Concrete Chimney Co., of Chicago, has an interior diameter of 17 ft. and rises to a total height of 270 ft. As the center of the stack is 55 ft. from the line of the building, the flue connection has a clear span of 40 ft. from the building to the opening into the stack. This stack has a capacity for taking care of ten additional boilers which will serve a 14,000-kw. turbo-generator unit when the next section of the plant is built.

Feed water for the boilers is obtained from the Duwamish River through a 10-in. pipe laid in a concrete-lined trench having a 6 x 10-ft. cross-section. This trench extends from an intake at the river, underground to the building, and thence under the longitudinal center line of the basement of the boiler room to pumps in the basement close to the transverse partition wall of the building. Two 8 x 10¼ x 10-in. steam-driven reciprocating pumps elevate the feed water from the 10-in. pipe to a 13,000-gal. steel tank carried in the upper part of the boiler room by a concrete platform tied into the building columns. The steam-supply pipe of each pump is arranged with a balanced valve operated by a float in the tank in such manner that the water level in the latter is maintained at a practically uniform height. A 4-in. motor-driven horizontal centrifugal pump is also installed for the same service.

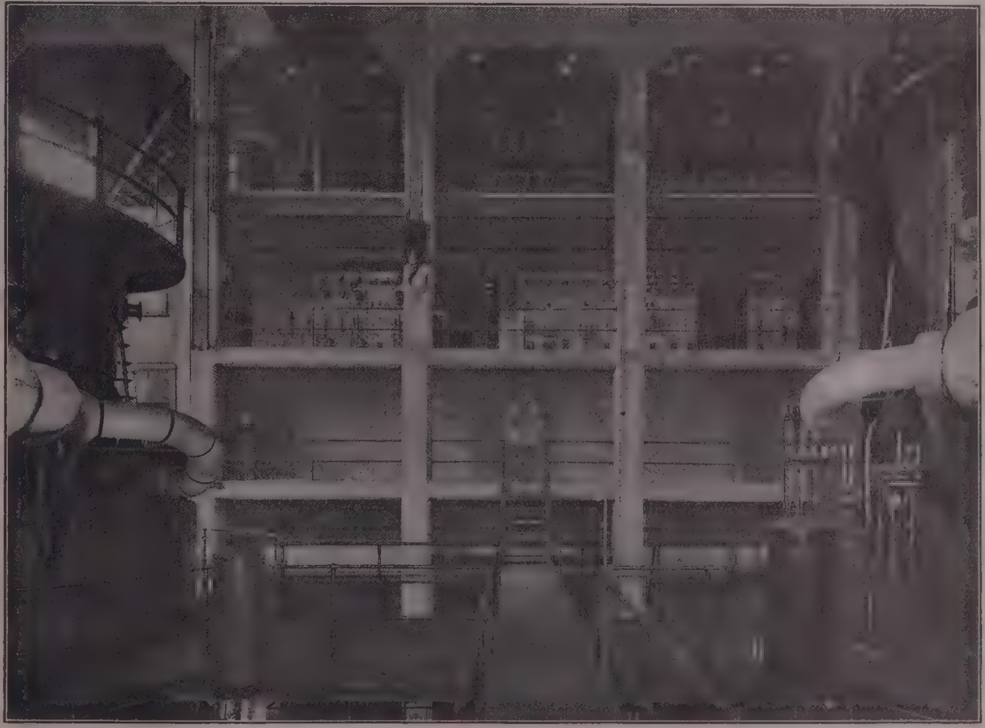
Each row of boilers is supplied by a separate system of feed-water pumps and connections. The three pairs of boilers serving the 3,000-kw. unit are supplied by either or both of two 14 x 9½ x 12-in. Blake feed pumps, which draw from a 3,000-h.-p. Cochrane heater that is supplied with make-up water from the overhead tank, or the pumps can draw directly from the latter. The heater is furnished with exhaust steam from the various steam-driven auxiliaries operated in connection with this unit. The discharge from the feed pumps connects with a 6-in. header that is carried overhead along the front of the boiler settings. Water is supplied to the rear steam and water drum of each boiler from this header by means of a 2½-in. connection controlled by a hand-operated globe valve. A 6-in. auxiliary feed-water supply line is also obtained by connecting the discharge of the feed pumps with the blow-off header under the boiler-room floor at the rear of each row of boilers. The lower or mud drum of each boiler is connected by three 2½-in. pipes to the main blow-off line, and the lower superheater drum has one 2½-in. connection to the same main for delivering any condensation that may take place in the superheater.


The Two Main Generator Units.

The arrangement of the boiler feed pumps and supply lines is the same for the row of boilers on the opposite side of the room as for the row of three batteries. The heater in this case has a capacity for supplying 5,000 h.p. in boilers and two 14 x 9½ x 12-in. Blake feed pumps are installed for this row.

Steam is taken from the superheater drum of each boiler through a 6-in. full-sweep connection to a header for each row of boilers. These connections are each fitted at the boiler with a 6-in. hand-operated non-return valve; and at the header with a 6-in. gate valve. The header for each row of boilers is carried on cast-iron brackets attached to the corresponding side of the reinforced-concrete columns which supports the coal bunkers. The headers rest directly on roller bearings on these brackets so they can move readily with changes in temperatures. The header for the row of three batteries of boilers is a 12-in. pipe, while the one for the row of four batteries is 12 and 14 in. in diameter. The smaller header is divided into two sections by a gate valve, and the larger header is divided into four sections by three gate valves; the two headers are also cross-connected at both ends of the boiler room, thus forming a ring system through which either row can deliver steam to either or both headers and in either direction. Normally, however, each row of boilers supplies steam to the unit on its corresponding side of the generator room, the steam headers extending through the partition wall between the boiler and generator rooms. The various steam-driven auxiliaries of each unit of the station are supplied with saturated steam from a 6-in. auxiliary header. The latter has a 2½-in. connection to the middle drum of each boiler and extends along in the rear of the row of boilers to the end of the boiler room next to the generator room. The two auxiliary headers are cross-connected in the basement at that end of the room so any steam-consuming auxiliary of either unit of the station may be supplied from either row of boilers. These auxiliaries are arranged to exhaust into the feed-water heaters, as has been explained, but they also have free exhaust connections to risers leading to exhaust heads above the roof of the building.

Two Holly drip systems, one for each row of boilers, are installed to deliver all condensation from the high-pressure steam piping back to the boilers directly. In general, a connection is made to these systems at every valve and every low point in the high-pressure steam piping. The water collected by these drips is carried to a receiver in the basement of the boiler room. It is then carried by the high-pressure steam into a discharge chamber placed up near the roof of the boiler room. From this chamber the water is automatically delivered to the boilers.


Operating Galleries in the Generator Room.

Generator Room.—One of the most significant features of the generator room is the fact that generating equipment with a normal capacity of 11,000 kw. and a guaranteed 50 per cent. overload capacity, or a total of 16,500 kw. is placed in a floor space 64 x 78 ft. in plan. This space also includes the various auxiliary apparatus for the two units, including the condensers, exciters and the equipment of a sub-station installed in connection with the station. On account of the limited space occupied by the two units the accompanying illustration, showing the interior of the generator room, was necessarily reproduced from two negatives and appears quite distorted.

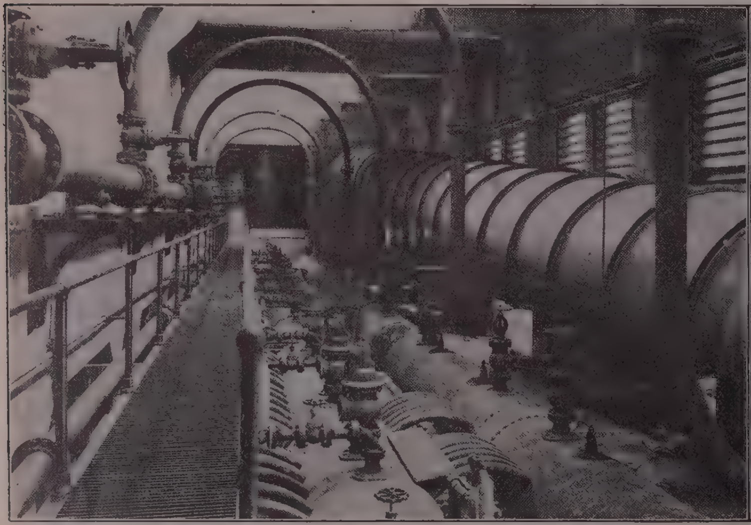
The two main units are Curtis turbo-alternators with three-phase, 60-cycle, 10-pole separately-excited revolving-field generators, designed to deliver current at 13,800 volts and to operate at a normal speed of 720 r.p.m. The speed of each unit is controlled by a hydraulically-operated governor, as developed by the General Electric Co., for large units, and is so arranged that the speed may be varied from the switchboard. The turbines operate on a normal steam pressure of 175 lb. with 100 deg. of superheat.

The turbine of each unit is served by a Weiss counter-current barometric condenser. The cooling water for the 3,000-kw unit is supplied by a centrifugal pump, direct-connected to a 10 x 12-in. high-speed Porter-Allen engine. This pump draws water through a 16-in. pipe extending from the intake at the river. The water passing through the main barometric tube is discharged against the pressure of the atmosphere into a hot well. A secondary barometric tube with a foot valve is provided which automatically maintains equilibrium in the condenser and serves to remove any water which might be carried into the dry-vacuum pump. The latter is of the horizontal tandem Weiss crank and fly-wheel type, with a 34-in. air cylinder and a 12-in. steam cylinder. The speed of this pump is controlled by a throttling governor arranged for variable speeds.

The condenser of the 8,000-kw. unit is supplied with 7,500 gal. of cooling water per minute by an 18-in. horizontal centrifugal pump driven by a 11 x 14-in. Porter-Allen high-speed engine. It has a Weiss dry-vacuum pump with a 48-in. air cylinder, an 18-in. steam cylinder and a 30-in. stroke. The water from this condenser is also discharged into a hot well. The size of a condenser of this type designed for high vacuum is indicated by the following data regarding the condenser for the 8,000-kw. unit; the exhaust connection of the turbine to the condenser chamber is 78 in. in diameter and rises to a height of 41 ft. above the floor of the generator room; the main shell of the condenser, with a diameter of 9 ft., has its top 54.5 ft. above the generator room floor, and the condenser receives 130,000 lb. of steam per hour when the unit is operating at the normal full load. The condenser equipment was furnished by the Southwark Foundry & Machine Co.

The overflow from the hot wells to which the water is discharged from the condensers passes into a tunnel, 8 x 12.5 ft. in cross-section, which extends transversely under the end of the basement of the boiler room, close to the partition wall between that room and the generator room. This tunnel is lined with concrete and extends for about 300 ft. across the land adjacent to the building to an outlet at the river, over 200 ft. down-stream from the intake pipes through which cooling water is supplied to the condensers. The cross-section of the tunnel is of sufficient size to permit the tunnel to be extended into the additional sections of the ultimate station as these sections are built.

The step-bearings of the two main units are supplied with oil from the same high-pressure system. Two 7½ x 2⅛ x 18-in. duplex high-pressure Worthington pumps are installed in the basement of the boiler room to furnish pressure to this system. These pumps are in duplicate, as either of them has sufficient capacity for the service required. The pumps deliver at about 1,300 lb. per square inch pressure into duplicate mains leading to the two units. A 3-in. by 5-ft. hydraulic accumulator is placed in this delivery system to maintain a uniform pressure in the latter. The step bearing of the 8,000-kw. unit is operated with the oil at a pressure of 1,000 lb. per square inch, and the step-bearing of the 3,000-kw. unit at a pressure of 460 lb. The pressure in the mains is reduced to that required in each case by a baffler in the supply pipes close to the bearings. The overflow from the step bearings is returned to either or both of two Turner oil receiving and filtering tanks. One of the latter has a capacity of 600 gal. and can filter at the rate of 20 gal. per minute; the other will hold 400 gal. and filter at the rate of 12 gal. per minute. The two high-pressure pumps have a suction connection with the storage tanks of both of the filters.


Steam Connections and Flue over Row of Boilers.

Front of Row of Four Batteries of Boilers.

The intermediate bearings on the two main units are supplied with oil under a pressure of 120 lb. by 9 x 3⅛ x 10-in. duplex Worthington pumps, installed in duplicate. These two pumps also take suction from the storage tanks of the two filters. A 3 x 6-ft. air tank is placed at each unit on the delivery pipe from these pumps to maintain a uniform pressure at the units. An emergency connection is also made between the delivery pipe of these pumps and the high-pressure oil main, in order that the one of the two pumps of the intermediate system, which is not supplying oil to the steady bearings, may deliver to those mains in an emergency.

The equipment of the entire station is supplied with lubricating oil from a complete separate system. This system is served by two oil pumps, in duplicate, with a 400-gal. oil tank in the monitor of the boiler room floating on the delivery system. A connection is carried from the latter to the high point of each unit to be supplied and branches are extended from this connection. The waste from the units is carried by gravity back to an oil sump tank under the floor of the boiler-room basement. The oil is lifted from this tank by air pressure, which is supplied by compressors in the basement, to a separate Turner oil filter from which the station oil pumps take suction.

Two air compressors are installed in the basement of the boiler room to supply air under pressure for various purposes about the station. These compressors are in duplicate, one being motor-driven, while the other is driven by a steam engine, thus insuring a supply of air under all operating conditions.

Two direct-current generators, a 40-kw. motor-driven and a 75-kw. engine-driven were installed to furnish excitation current for the 3,000-kw. main unit. A 120-kw. motor-driven exciter was then added when the 8,000-kw. main unit was installed. These exciters are all three placed on the first gallery floor, which is at the same level as the operating floor around the main units. On this floor are also mounted two 500-kw. motor-generator sets for supplying 600-volt direct-current locally to the street railway system. Two 100-kw. transformers are placed on this floor to supply current at 2,300 volts for lighting and to drive small motors in the station. Two 500-kw., 13,800 to 2,300-volt water-cooled transformers installed on the first floor of the gallery furnish current for the local Georgetown supply.

The second gallery floor, except for an office at one end, is entirely devoted to wiring, and is separated from the generator room by a reinforced-concrete partition. The third floor contains the switchboard, from which the operation of the electrical apparatus in the generator room is controlled. Motor-operated oil switches on the high-tension connections of the station are placed on the fourth gallery floor. The top floor is given over to lightning arresters, static dischargers and outgoing transmission-line connections.

The 13,800-volt current delivered by the main generators is carried out of the station at that voltage to two substations near the business section of the city. This voltage is either stepped down to 2,300 volts in these substations for local distribution or transmitted through these substations at 13,800 volts to other substations of the company's system.

The main units are arranged for remote control from panels on the third gallery floor. A cable from each phase of both main generators is carried from the latter in brass pipes leading to conduits under the floor of the generator room. These conduits extend to the end wall of the building at the rear of the galleries, and the cables are carried up a 12-in. space between this wall and the gallery floors to motor-operated oil switches on the fourth floor of the gallery. On the third floor of the galleries are also located panels controlling the railway motor generator and the railway feeder circuits; also panels for local light and power service. All panels of this switchboard are of blue Vermont marble mounted with standard General Electric switches and recording and measuring apparatus. The gallery floors are entirely of reinforced-concrete and are reached by stairways of concrete, so the gallery structure is fully fireproof.

The end of the generator room on the side of the building where the next section of the station is to be built has been covered temporarily with corrugated galvanized sheet iron. As the other sections of the station are added the operating galleries will be extended along the end of the connected buildings, so the equipment in each section of the entire long generator room may be controlled from the corresponding section of the galleries. Toilet and bath rooms for the generator room employees are placed at the end of the first floor of the present galleries, and directly over these are locker rooms. On the next two floors above are offices for the chief engineer and electrician.

The generator room is served by a 50-ton motor-driven crane, built by the Northern Engineering Works, of Detroit, Mich. One runway of this crane is at the top floor level of the galleries and the other runway is carried by columns along the partition wall between the boiler and generator room. The main equipment in the latter room can thus all be reached by this crane. A 20-ton crane operates over the first floor of the galleries to serve the exciter and substation equipment on that floor.

The station was designed by the Boston office of the Stone & Webster Engineering Corporation. The construction of the building and the erection of the mechanical equipment was carried on under the direction of the Seattle office of that corporation, of which Mr. M. J. Whitson is superintendent. Mr. H. H. Barter was engineer in charge of the installation of the equipment. The station is operated by the Seattle Electric Co. The electrical equipment of the entire station was furnished by the General Electric Co.

Direct and Indirect Methods of Electrical Purification of Water.

The employment of electrical energy, either directly or indirectly, in the purification of water has received a considerable amount of attention in recent years, but misleading statements concerning the results of such methods have often been made. It is true that at least one of these methods is highly efficient as a germicide, but thus far engineers generally have considered other means of water purification more economical. A paper recently presented before the Franklin Institute by Mr. Henry Leffmann covers certain phases of what has been done, and from this paper the following notes have been taken:

As it is not necessary to review the history of the application of electrical currents to water purification, nor to describe even briefly the numerous patents that have been granted for such purposes, Mr. Leffmann referred only to some that have come under his observation, in consequence of having been asked to make expert investigations of them. Some attempts have been made to remove the mineral impurities from water by taking advantage of the electrolytic powers, but most processes have been intended to kill the microbes. The ordinary inventor has, Mr. Leffmann said, proceeded upon his generally superficial knowledge that the disease-carrying power of water is dependent upon bacteria, and that electricity in sufficient strength is fatal to living matter.

In some of the processes the method has been the crude one of simply passing electric discharges through the water, hoping to kill the bacteria by direct shock. Thus, in one patent which was submitted to Mr. Leffmann's consideration a few years ago the inventor proposed to have electrodes passed into the water main through insulated sockets and discharge a succession of sparks across the stream. The impracticabilty of the method on anything but the most minute scale seems not to have appeared to him.

Several methods of water purification by means of electrolysis have been demonstrated. In these aluminum electrodes have been used, and more or less loss of the metal has occurred, it being converted into aluminum hydroxide. This produces its usual effect, that of combining with the organic matter and entangling the suspended substances so that the water after treatment can be subjected to a rapid filtration and will show material improvement in microbic content, especially if the amount of suspended matter and microbic content were previously high. On waters containing but little suspended impurity, living or dead, the purifying action is relatively low. The constant loss of the electrode is, of course, a most serious item of expense, generally overlooked in the experimental plants.

Two of the plants in which aluminum electrodes were used may be described with advantage in some detail, as some incidental features are of interest. In one, large aluminum plates, 2 ft. long and several inches wide, were immersed in the water in a tall jar and the current passed through. The experimenters selected, probably with a view of more profoundly impressing inexperienced observers, very muddy water from the street gutter in front of the building in which the plant was located. The current seemed to cause the mud to collect and settle rapidly, and the water became soon fairly clear, but analysis showed ammonium compounds and nitrates in abundance, and it was evident that the purification was nominal.

In another case Mr. Leffmann was asked to examine a plant that was in operation in Philadelphia and found a very elaborate installation, mostly of closed vessels, some of which were taking the street current through ammeters and voltmeters, and from others of which a clear water could be drawn in considerable amount. The operators showed specimens of water containing a large amount of sediment, mostly in flakes, which were claimed to be the "scale-forming ingredients." Mr. Leffmann at once recognized that the precipitate was aluminum hydroxide, when he found aluminum electrodes were being used, so the process was, of course, unsuited to the purposes for which it was devised.

In the operation of the Anderson process of purifying water by agitation with metallic iron attempts have been made to get more powerful action, that is, more rapid solution of the iron, by making the latter the positive pole of an electric system, but no practical advantage seems to have been attained. Recently a process has been patented in which an electric current is passed from an inner to an outer pipe, the water flowing through the annulus, but Mr. Leffmann has no practical knowledge of this method.

The most practical benefit of the application of electricity to water purification will come, Mr. Leffmann believes, from the indirect methods in which the electrical energy is used to produce an active disinfecting agent, and this agent is then applied to the water. Of all the processes of this type, those which produce ozone, he states, seem to be most useful. The material from which ozone is obtained—air—is in unlimited supply, and the addition to water cannot be regarded as being dangerous, since if present in excess it soon reverts to the condition of ordinary oxygen.

The principal problem in this method is the economic production of ozone. This modification of oxygen can be obtained by several methods of different types, but those in which electricity is employed seem to be alone applicable to the processes in question here. For the purpose high-tension currents are most economical, and the best yield is obtained by the so-called "silent discharge." It is now known that a spark or arc discharge will produce nitrogen oxides which are corrosive. It has also been determined that the air intended for production of ozone should be dry, otherwise hydrogen dioxide will be formed. The principal mechanical difficulty encountered in producing ozone on the large scale by means of the electric discharge is to secure a suitable dialectric. Glass, porcelain, rubber and other materials have been tried, but are so liable to fracture or perforation that serious interruptions of operation frequently occur. Continuity of action is very important in commercial processes, such as the purification of water, and when a large unit of the plant is out of use, in order to install a new dialectric, the condition is annoying.

The inventions of Vosmaer seem to overcome the difficulty, for he avoids the use of a special dialectric, employing only the dry air which is to be ozonized. The discharge takes place from thin metal strips on which are sawlike teeth. These strips are held firmly in the center of metal pipes by porcelain insulating sockets. Many of these pipes are combined in parallel, the strips being all connected with one pole and the pipes with the other. An alternating current of high potential is allowed to flow through the arrangement, almost all the current passing by silent discharge, although at times a spark passes, but as there is no permanent dialectric no damage is done. The sparking is too seldom to produce damage or any appreciable amount of objectionable gases. The drying of the air may be done by any of the known methods; preference is given by Vosmaer to refrigeration, by means of an ordinary ice machine.

A plant capable of purifying many thousand gallons in 24 hours has been for some time in operation on the west bank of the Schuylkill River at the foot of Locust St., Philadelphia.

The water is first roughly filtered. This operation is merely intended to remove the grosser suspended matter, as the ozone process proper does not accomplish this. As the main part of the operation is the destructive action of the ozone on the bacteria, it is not necessary for the preliminary filtration to be nearly so close as when the latter is the sole reliance, as in ordinary filter plants, hence the filter area in the ozone plant is relatively very much smaller, the rate of filtration being so much greater. The filtered, or perhaps it may be called strained, water is passed into aërating towers. These are tall, narrow vessels, into which the water enters at the top and the ozonized air at the bottom, the latter under considerable pressure. In the experimental plant above mentioned an exhibition mixing tower has been installed. This is a glass tube about 16 ft. high and 10 in. in diameter. In this the admixture of the ozone current with the water current occurs to a marked degree. Upon the thoroughness of this mixing, Mr. Leffmann says, depends in large part the thoroughness of the purification; the water escapes at the foot of the mixing tower, clear and practically sterile. It sometimes contains a small amount of ozone in solution, but this, he stated, is not objectionable and soon disappears, either by conversion into ordinary oxygen or by combination.

The advantages of the process he summarized as follows: No objectionable chemical is introduced into the water. Large filter beds are not required. The operation expenses are not high. The plant occupies a liimted area and the operation is simple and easily comprehended. The plant may be enlarged by the addition of new units without disturbing the original units. The sterilization is rapid and certain. The plant may be placed at any convenient point.

The process seems to Mr. Leffmann to find even more valuable application to the purification of sewage than to ordinary water supply. The extensive use of water in domestic life, with the increasing sources of pollution, give importance to every method of purification, and processes that seem to be founded on scientific principles and seem capable of practical operation on a large scale, and to involve low operative cost, limited land area and freedom from dangerous chemicals deserve careful investigation.

Many tests of the bacteriological efficiency of the plant have been made. Some made by Mr. Leffmann showed that the water as discharged from the ozonizer is practically sterile. Tests made by other investigators are stated by the paper to have shown equally satisfactory results.

The Poetsch Freezing Process has been employed in sinking two shafts for the de Wendel colliery at Klein Rosseln, near Forbach in Lorraine. Previous difficulties at this place with the Kind-Chandron trepan system and with the ordinary method in which reliance is placed on pumps for removing water led to the adoption of the process before the work was begun. An advance pit 33 ft. in diameter and secured by a temporary iron lining was sunk by hand to a depth of about 80 ft. Twenty-seven holes were then started at that depth, equally spaced on the circumference of a 24-ft. circle. Two of them were bored with a diamond drill so as to show the character of the materials penetrated, and the others were sunk by churn drills. The holes were carried down mainly through sandstones and conglomerates to a depth of 613½ ft. below ground, and in them were placed the pipes for the freezing fluid, a 10-per cent. solution of chloride of calcium. The pipes had a total length of 2.6 miles and a cooling surface of 16,300 sq. ft. The shaft was sunk at the rate of 21 ft. per month, inclusive of the time spent in boring and freezing. The shaft was lined with tubbing up to the ground-water level and with concrete above that point. The second shaft was sunk in the same manner, but the boring of the freezing holes was started considerably lower.

A Combined Refuse Destructor and Electrical Generating Station in England.

A combined refuse destructor and electrical generating station was placed in service last year at Greenock, England, and has since been giving quite satisfactory service. The refuse of the city was originally dumped at a point which caused much complaint; an additional amount of electrical energy for power and lighting purposes was also necessary. In order to avoid the nuisance caused by the dump and to provide for the additional electrical power needed, the decision was made to erect a destructor in connection with a generating station and to use such heat as was available from the destructor for steam-raising purposes. As the capacity of the existing generating station could not be readily increased, provisions were made at the new station for additional equipment to meet future requirements, and the buildings were constructed so as to lend themselves to easy extension. Contracts for the erection of the destructor plant were awarded to the Horsfall Destructor Co., Ltd., in April, 1906, and the contracts for various other parts of the station were distributed among various other concerns. These works have recently been described in the "Engineer," of London, from which description the following notes have been taken.

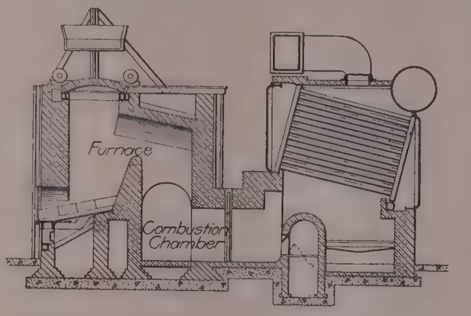
The site of the plant is such as to facilitate the most economic delivery of the refuse that is collected, and is provided with a railway siding to insure easy delivery of coal and other supplies. The buildings are of permanent construction and are laid out in four bays. The destructor furnaces occupy the bay nearest the street entrance, which bay is 40 x 110 ft. in plan and 41 ft. high; the two central bays accommodate two sets of boilers for destructor and coal firing, respectively; the east bay, which is the largest of the four, contains the electrical generating equipment. A pump room which serves both sets of boilers adjoins the power station, and the economizers, of which two are provided, are housed outside the main building. A stack, 150 ft. in height by 10 ft. in internal diameter, is situated at the end of the boiler house. A concrete retaining wall and a water reservoir have been built at the south end of the site, and water is conveyed by an 18-in. pipe from the reservoir into the power station for condensing purposes.

The destructor plant consists of six large cells and combustion chambers and three water-tube boilers; the arrangement is such that each pair of cells, with its boiler, forms a unit which can be worked independently. Any unit of the plant can therefore be shut down for repairs or cleaning, without interfering with the working of the other units. By firing the two cells of each unit alternately a steady steam pressure is maintained in the boiler, while the combustion chamber is also kept at a sufficiently high temperature to cremate thoroughly the noxious gases which escape from the newly charged refuse.

The top-feed method of storing and charging the refuse into the cells has been adopted and is especially designed to reduce manual labor to the lowest possible minimum. The refuse is delivered in the cells from the cars in which it is brought to the plant without re-handling of any kind, thus not only affecting a saving in the cost of labor, but also insuring great cleaniness. An elevated driveway entrance extends along one end of the destructor house and contains two specially-shaped hoppers over a dumping pit. The refuse is discharged from the carts through these hoppers into tight, closed storage skips in the pit below. The latter has accomodation for four of these skips, which are arranged to move across it on rails. As each skip is loaded it is lifted by a 3-ton overhead crane and carried into the building, where it is deposited on a storage platform until its contents can be destroyed. This storage and charging platform extends the full length of the set of furnaces, directly over the latter, and has accommodation for 80 skips. The storage of refuse is thus accomplished in the closed skips on this platform entirely separated from the heat of the destructor.

The method of charging the furnace is as follows: A skip of refuse is lifted from the storage platform by the overhead crane and is placed on a movable cradle surmounting the cell. Under the superimposed weight the cradle subsides and simultaneously a system of levers and balanced weights lift the water-sealed door from its seat and draw it to one side on rails, thus permitting the lower edge of the movable cradle to descend to the mouth of a charging door-way in the top of the cell. The bottom of the skips are hinged, so when the skip reaches the proper position the bottom may be dropped back and the contents of the skip deposited directly into the furnace. The crane then lifts the empty skip, and the water-sealed door, actuated by a balance weight is drawn back to its seat. The whole operation of depositing and withdrawing a skip occupies less than a minute. The furnace door is open a few seconds only, so any inrush of cold air, with a consequent reduction of temperature, is reduced to a minimum.

The furnace grates are directly under the chargdoor, the contents of the skip falling directly upon them. The grates slope from the back to the front, and have an area of 25 sq. ft. in each cell. The grate bars are perforated with a large number of small holes, through which an air blast is forced by means of electrically-driven fans. Although air blast has generally been considered one of the best means of insuring complete combustion in destructor furnaces, it has heretofore been delivered at comparatively low pressures. The grate and fans in this plant are constructed, however, for a specially high pressure, and are fully expected to show a distinct gain in efficiency over the older system. The fans, of which there is one to each furnace, are coupled directly to variable speed motors of a totally enclosed type. The starting and regulating switches of these motors are fixed conveniently to the furnace doors and a throw-over switch is actuated in such a way that the opening of the door automatically stops the fan. Incidentally, an attempt has been made to improve the atmospheric conditions existing in most destructor works, by taking the air supply for the furnaces from the under side of the storage platform. The air inlets are also arranged so all dust and fumes omitted during the process of clinkering are drawn in and delivered back to the fires. Auxiliary steam jet fittings for steam blast have been provided, but they are only intended to be used in the event of a breakdown of the fans.



Section through a Destructor Cell.

The time required to cremate a charge properly varies from 1½ to 2 hr., according to the class of refuse, and at the end of the period the fire is cleaned through a clinkering door at the front of each cell. This door is of specially strong construction and is provided with two small doors through which the fires can be adjusted and stoked without opening the main door. The clinker is withdrawn from the furnaces into buckets on a telpherage system, which enable it to be delivered either directly to an adjacent clinker crushing and screening mill, or deposited in heaps until required.

A main flue of large area conducts the hot gases from each pair of cells through a combustion chamber of the boiler associated with it; a Horsfall dust catcher being built between the combustion chamber and the boiler. All the flues are lined throughout with fire brick, and specially made fire-clay brick, set in fire-clay cement have been employed in the furnaces. Marine water-tube Babcock & Wilcox boilers, constructed for a working pressure of 200 lb. per square inch and fitted with superheaters designed to raise the temperature of the steam to 500 deg. Fah., have been installed. Arrangements are made to meet any very special demand for steam by auxiliary grates fitted for coal firing. A by-pass also connects the destructor chamber directly to the main overhead flue, so that in the event of a breakdown of a boiler, or an excess of steam being generated, the whole or a portion of the hot gases from the chamber may be taken by this by-pass instead of through the boiler. The gases en route from the latter to the stack pass by the way of the overhead main flue to a Green economizer in two sections of 120 tubes each. A by-pass is further provided, in order that the gases may be sent directly to the stack.

Steam is taken from the superheater of each boiler by a connection to a main header that supplies the electrical generating equipment. The feed-water piping is connected by a branch to a system supplying the coal-fired boilers in the adjacent bay, the arrangement being such that the destructor boilers can be fed either through their own economizer, or from the hot feed-water main from the coal-fired boilers.

The pump house contains two three-stage electrically-driven Worthington pumps and a Weir double-acting steam pump. The storage tank of 12,000 gal. capacity is placed over the pump room, and a combined water-softening and oil-extracting plant is provided to treat the feed water. The two coal-fired boilers are of the Babcock & Wilcox double-drum type; each boiler being capable of evaporating 18,000 lb. of water per hour; each boiler is equipped with a superheater and a chain grate stoker. The electrical-generating equipment has been operated since the formal opening of the plant on October 30, last, without difficulty and with satisfactory economy. While everything is said to point to similar and even more satisfactory results from the destructor and generating station combined, it was considered at the time the article from which these notes was prepared to be too early to make public definite results.

Two direct-coupled Belliss-Westinghouse generating sets, each capable of producing 750 kw. when supplied with steam at 200 lb. pressure, have been installed. Each of these units is driven by a 1,140-h.p. triple-expansion high-speed enclosed type engine. Arrangements are also being made to remove two 400-kw. generating sets including boilers, engines, dynamos and condensers from the existing station to this new one. The latter is thoroughly equipped with modern auxiliaries and is every way designed to deliver current economically.

The new works were designed and erected according to the plans and specifications of Mr. James A. Robertson, borough electrical engineer of Greenock.

A Smoke Nuisance due to the use of fuel oil in a steam shovel and in portable boilers located near a residence has recently been enjoined by the California Court of Appeals, and damages against the owner of the machinery have been awarded to the householders.

Factory Building of the Rushmore Dynamo Works, Plainfield, N. J.

A simple type of reinforced-concrete factory building, which allowed of rapid and novel construction, was completed last fall for the Rushmore Dynamo Works, on South Ave., Plainfield, N. J. The floor systems are designed so as to do away with lintels above the windows and thus allow the windows heads to be placed one inch below the bottom the the floor slab. The column construction permitted the curtain walls between the plasters, the windows and the floor slab to be cast independently of the reinforced-concrete skeleton of the building.

The factory is 47 ft. wide, 220 ft. long and two stories high, divided longitudinally into two bays by a center line of columns. The latter, which are 18 in. square in the first story and 12 in. square in the second story, are on 18-ft. 8-in. centers and carry a 12 x 30-in. girder. The floor beams at right angles to this girder and the line of columns, are on 6-ft. centers, each one carried independently by a pilaster in the outside wall at one end, and by the girder or directly by one of the center columns on the other end. The beam span center to center of columns is 23 ft., the depth 24 in. and the width 8 in. The floor slab is 4 in. thick.

The roof system is similar to the floor system just described except that the dimensions are smaller in accordance with the smaller load.

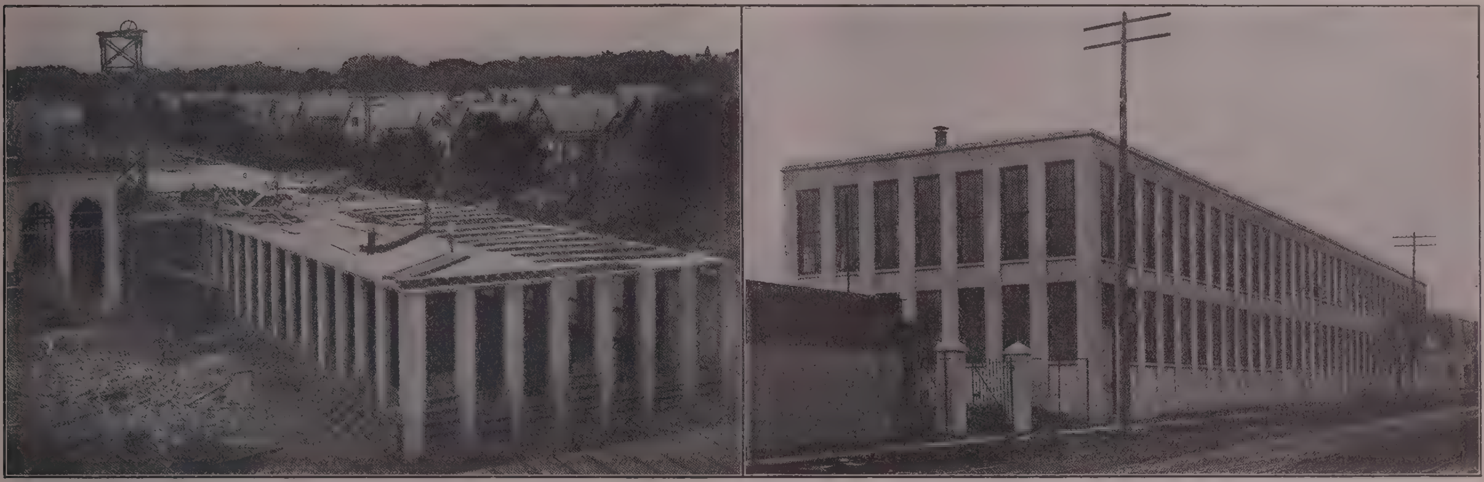
The dimensions of the pilasters are the same in both stories, those in the long sides of the building measuring 1 ft. x 2 ft. 2⅜ in., those in the short sides 1 ft. x 2 ft. 4½ in.

One of the accompanying photographs shows clearly the method used in construction. Sufficient forms were provided for putting up one-fourth of the building at one operation, that is to say, one-half of the length of the structure through a height of one story. The columns were carried up first without any wall filling whatsoever, between them, and after the floor system had been cast and the forms removed, the construction consisted of nothing but a sheet of concrete carried by the lines of detached pilasters on the outside edge and by a center line of columns in the interior. When all of the columns of the first story were cast and the floor of the second story completed the same column forms, already twice used, were erected on the floor of the second story, the columns cast and the roof system put in place.

While the work in the second story was in progress, the curtain walls beneath the windows and between the pilasters in the first story were being cast in an independent set of forms. The curtain wall was 6 in. thick, 4 ft. 6 in. high and was well bonded to the pilasters in slots left in the latter by cleats which had been provided in the lower parts of the pilaster forms.

The design adopted of having a pilaster for every floor beam, makes it unnecessary to provide heavy beam reinforcement between the pilasters for carrying any considerable weights, since the only loads are the light curtain wall and the window. These are amply provided for by the reinforcement of the floor slab which is carried continuously to the outside building line. The illustration shows the manner in which the design was carried out and how it is possible to place the lighting area up to the ceiling line. The method of operation is also distinctly shown, the floor of the second story being complete, the curtain walls of the first story being cast, and the column forms for the second story lying on the second floor ready for erection for the final lift. On the left of the photograph showing the construction of the factory, is a smaller building erected at the same time and designed to house the power equipment. As will be noted it was constructed after the same fashion as the other building, the columns being carried up continuously and the roof cast before putting in the curtain walls between the pilasters.

The building was designed and constructed for the Rushmore Dynamo Works, of which Mr. S. W. Rushmore is president, by Tucker & Vinton, New York City, on a cost plus-a-premium contract.



Two Views of the Rushmore Dynamo Plant, Showing Method of Construction and Completed Building.

THE COMPRESSIVE STRENGTH OF CONCRETE and mortar as influenced by the proportion of water, was investigated recently by Herr Brabandt, a German railway engineer, the conclusions being published in the "Centralblatt der Bauverwaltung." The test cubes were 30 cm. (about 12 in.) on a side, and were made in accordance with the rules of the "Deutsche Betonverein." They were stored in a shed under wet sand and were tested after 28 days. The test results showed a certain proportion of water which gave the greatest strength, either more or less water giving poorer results. The conclusions drawn by Herr Brabandt from his tests on concrete are as follows: 1. The most favorable quantity of water for the mixtures commonly used is about 15 to 20 per cent. of the volumes of cement and sand. 2. Poor mixtures need less, rich ones more water. 3. The moisture already contained in the raw materials must always be considered. 4. The absorption of water by the gravel, ballast or broken stone must be taken into consideration. The quantity of water thus required must be determined beforehand by tests and added to the quantity needed for the mortar. 5. In cold seasons less water, in warm weather more water must be used. 6. With very rich mortar mixtures, with more cement than sand, the amount of water demanded is considerable, and may even reach 30 per cent. 7. It seems wise to determine the amount of water by tests, at least when required for large buildings, and to regulate it by general specifications.

Operating Results of the Producer-Gas Pumping Plant at St. Stephen, N. B.

A producer-gas pumping plant has been in service for some time in connection with the water-works system of St. Stephen, N. B. This plant consists of duplicate units, each unit including a suction producer of the Pintsch type having a normal capacity of 135 h.p. and equipped with a vaporizer, a scrubber and a cleaner; a 125-h.p. horizontal single-cylinder, four-cycle Olds gas engine and a double-acting triplex power pump with a capacity of 1,250 gal. per minute when running at 32 r.p.m. The contract required a duty of 115,000,000 ft.-lb. per 100 lb. of coal fired, the result to be determined by a three-day test with the engine running eight hours each day and banked the remaining 16 hours. The design and constructional features of the plant were described in a paper presented before the American Water Works Association a year ago by Mr. F. A. Barbour and reprinted in The Engineering Record of July 20, 1907. Results of tests of the equipment were not available at that time, due to incompleteness of the plant, but a test was made on October 10, 11 and 12, 1907, as nearly in accordance with the contract requirements as the maintenance of the water-works system would permit. The results of this test were given in a paper by Mr. Barbour before the recent convention of the association, from which paper the following excerpts have been taken:

The Pintsch suction gas producers are each equipped with an independent vaporizer heated by gas between the generator and the scrubber. Each of them has a shaking-basket grate with an area of 5.4 sq. ft. or 0.04 sq. ft. per nominal horse-power of generator. The horizontal area of the generator is 4.9 sq. ft., equal to 0.036 sq. ft. per nominal horse-power of generator, and its cubic capacity up to the elevation of the gas up-take is 14.5 cu. ft., equal to 0.11 cu. ft. per nominal horse-power. The total cubic capacity of the generator is 32.5 cu. ft.; of the scrubber, 84.8 cu. ft., and of the cleaner, 63.2 cu. ft., giving the following capacities per nominal horse-power: 0.25 cu. ft. for the generator, 0.63 cu. ft. for the scrubber and 0.47 cu. ft. for the cleaner. The engine is of the single-cylinder, four-cycle, horizontal type with a 22 x 28-in. cylinder. Chestnut-size Scotch anthracite coal containing 1.17 per cent. of moisture, 7.60 per cent, of volatile matter, 83.64 per cent. of carbon, 7.59 per cent. of ash, and with 12,400 B.t.u. per pound was used.

The contract permitted the refiring of the salvage screened from the material dropping from the side doors of generator in poking the fire. The amount of this salvage is a noticeable feature in the operation of the plant, Mr. Barbour said. It depends largely on the attendant, but also on the type of grate and the opportunity for shaking down and freeing the fire of ash without using a bar above the grate.

The statement, often made, that the labor in firing a producer is much less than in the case of a boiler, Mr. Barbour believes is true, except as its truth is modified by the labor of screening and refiring the salvage. It is to be noted that the producer is fired from the upper floor, while the ashes are removed at a lower level and must be lifted for refiring at a considerable expense. When, as at St. Stephen, the salvage amounts to 25 to 40 per cent. of the coal fired, the labor saving over steam is considerably offset, and it may be predicted that one man cannot handle an apparatus such as that herein described. In short, unless the fuel fired is kept at a low figure, the labor account will be no less for a producer plant than for a steam plant. The material recovered is equivalent in thermal content to a considerable percentage of the original value of the coal per unit of weight and therefore well worth refiring. The actual labor in firing the original fuel is extremely small. During the test about 175 lb. were added at two-hour intervals, and the total time of attendance on the generator—aside from screening salvage—was less than one hour per day.

A uniform fuel bed is essential to the production of gas of good quality, and adequate provision for poking of the fire should be provided. For this purpose holes through the top of the producer are of value and should not be omitted. With such holes and a shaking grate, which will pass the ash without making necessary the use of the lower doors, the salvage can be materially lessened. The ash proper which passes the grate is extremely small in quantity and demands little labor in its handling.

The steam formed in the vaporizer is led to a jet and mixed with air, the mixture being carried centrally under the grate to provide even distribution through the overlying fuel. The steam jet working under a pressure of less than 1½ lb. is designed to secure a uniform mixture of air and steam in excess of that required for the operation of the producer, so that under any varying load conditions the mixture may be the same, while the quantity drawn into the producer changes in accordance with the demands of the engine. This is a most important provision, particularly in plants working with variable load. Originally the excess steam was led through pipes to the outside of the building, but apparently this piping disturbed the balancing of the mixture in the steam jet and at the present time the excess steam, which is hardly noticeable, is discharged close to the jet.

The total water used by the vaporizer was about 0.25 lb. per pound of coal burned, and it is estimated that about two-thirds of this amount actually entered the producer. The water used in the scrubber during the test was considerably in excess of that actually necessary, being equal to about 7.3 lb. per hour per nominal horse-power of producer.

The cleaner has a capacity of about 0.47 cu. ft. per nominal horse-power of producer, and in the guarantee of final cooling of the gas and the removal of condensed moisture and tarry products is a most valuable adjunct to a plant using American anthracite.

In the operation of the engines one of the most important items is that of the water used in cooling. During the test the amount used was excessive, partly owing to a desire to maintain an absolutely safe temperature and partly to the fact that the valves on the water piping were not adapted to close regulation. Entering the engine at a temperature of 44° Fahr. and leaving with an average temperature of 72° Fahr. the quantity per minute equalled 23 gal., and the heat carried off in this way—partly from the cylinder and partly from the exhaust head—amounted to about 37 per cent. of the total heat units in the coal fired. Including the water used in the scrubber and in cooling the engine 24.8 gal. per minute were required, or about 160 lb. per brake-horse-power hour. If the discharge temperature of the cooling water had been run up to 150° Fahr., the quantity might have been reduced to one-fourth that actually used in the test and the total water required in the plant reduced to about 40 lb. per brake-horse-power. In the regular operation of the plant the discharge temperature of cooling water is carried to 120° Fahr., and with a little closer attention could be carried to 140° Fahr. It is evident that in any case the amount of water necessary for the operation of a gas plant similar to that under discussion is larger than what would be required for a steam plant of equal capacity and of reasonably high efficiency. Of course, by circulating the same water through cooling towers the amount might be reduced to a minimum, and in the case of large engines pumping against high pressures it may be advisable to lessen the work of lifting this water by using an independent pump attached to the engine, operating against a light pressure.

TABLE 1, CONDITIONS AND RESULTS OF THREE-DAY TEST.

	October 10-11.		October 11-12.		October 12-13.		
Duration of Test.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	
Engine running	8 9	7 53	10 38	8 1	8 2	10 2	
Fires banked	15 56	16 ..	13 18	16 ..	16 ..	14 ..	
Fuel.							
Coal used in running, lb	721.75	704.50	845.50	725.50	638.25	839.25	
Coal used in banking, lb	14.50	36.50	44.00	11.50	14.00	14.00	
Total coal, lb	736.25	741.00	889.50	737.00	672.25	853.25	
Salvage from screening, lb	239.00	266.50	368.00	311.50	185.00	202.00	
Salvage per cent. of coal	39.50	26.00	41.50	42.10	28.20	23.60	
Coal per hr. of running, lb	88.60	89.40	79.50	90.50	81.90	81.20	
Coal per hr. of banking, lb	0.91	2.28	3.35	0.66	0.88	1.00	
Water.							
Water used in compressing air, both units, gal.	3,600.00		6,000.00		3,840.00		
Water used in blowing hot both units, gal	8,200.00		11,600.00		9,800.00		
Time of blowing hot, minutes	17.50		24.50		20.50		
Water used in each vaporizer, gal. per hour	2.70		2.70		2.70		
Water in each vaporizer, per lb. of coal burned, lb	0.27		0.25		0.26		
Water used in each scrubber, gal. per hour	105.00		105.00		105.00		
Total water used in both scrubbers, gal	1,900.00		1,680.00		1,960.00		
Water used in scrubber, per hp. of producer, lb. per hour	7.30		7.30		7.30		
Water used in cooling each engine, gal per minute	23.00		23.00		23.00		
Total water used in cooling engines, gal	25,000.00		22,100.00		25,700.00		
Per cent. of water pumped	1.80		1.80		1.90		
Total water used in plant, gal	38,800.00		41,400.00		41,500.00		
Per cent. of water pumped	2.90		3.40		3.10		
	October 10.		October 11.		October 12.		
Pumps.	No. 1.	No. 2.	No. 1.	No. 2.	No. 1.	No. 2.	
Revolutions	15,652.00	15,417.00	19,440.00	15,768.00	15,668.00	19,676.00	
Revolutions per minute	32.00	33.13	30.47	32.78	32.51	32.69	
Discharge per revolution by displacement, gal.	40.62	40.62	....	....	....	....	
Slip determined by preliminary test, per cent.	6.20	1.70	....	....	....	....	
Actual discharge per revolution, gal	38.10	39.93	....	....	....	....	
Discharge per minute, gal	1,219.20	1,322.88	1,160.91	1,308.91	1,238.63	1,305.31	
Discharge per minute, less water used in cooling, 24.80 gal	1,194.40	1,298.08	1,136.11	1,284.11	1,213.83	1,280.50	
Total gallons pumped to reservoir	584,062.00	613,992.00	724,838.00	617,657.00	585,066.00	770,867.00	
Pressures	No. 1.	No. 2.	No. 1.	No. 2.	No. 1.	No. 2.	
Force main, feet	164.80	168.20	166.00	167.00	166.70	166.70	
Suction lift, feet	12.69	11.90	11.65	11.19	13.42	12.67	
Total	177.49	180.10	177.65	178.19	180.12	179.37	
Duty. In million foot pounds, based on plunger displacement, less slip and cooling water.	No. 1.	No. 2.	No. 1.	No. 2.	No. 1.	No. 2.	Average.
Per 100 lb. coal fired during run	119.78	130.90	126.26	126.44	133.52	137.41	129.05
Per 100 lb. of coal, including banking	117.43	124.46	120.01	124.47	130.74	135.15	125.38
Per 1,000,000 B. t. u. in coal fired during run.	96.60	105.57	101.82	101.97	107.68	110.80	104.08
Per 1,000,000 B. t. u., including banking	94.70	100.71	96.78	100.71	105.44	109.00	101.20

By a comparison of the indicated power and the work done in pumping it is estimated that a mechanical efficiency of approximately 80 per cent. was developed by the pumps.

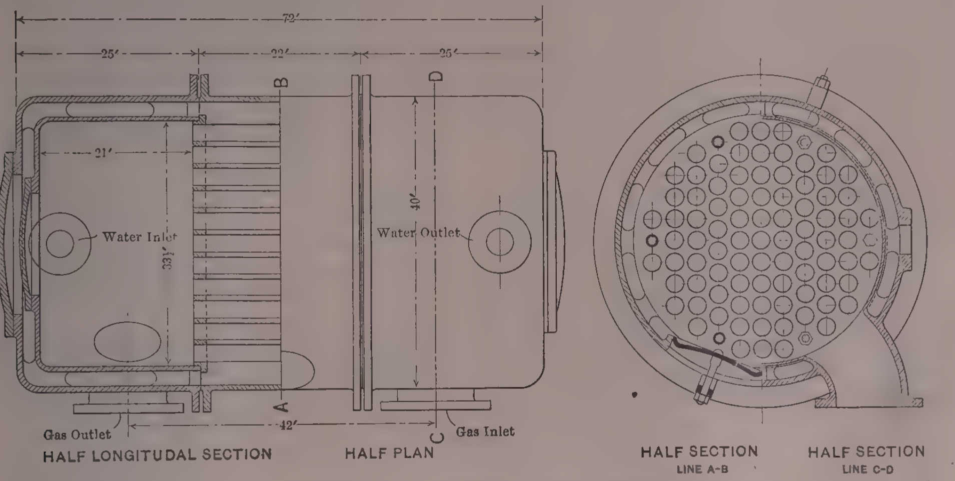
The average duty obtained during the hours of running was 129,000,000 ft.-lb. per 100 lb. of coal, equal to 1.53 lb. per brake-horse-power at the water end of the pump, or, allowing 80 per cent. efficiency of the pump, equal to 1.22 lb. per brake-horse-power of the engine. In this connection the fact should be emphasized that both the producers and the engines were running at about two-thirds their rated capacity—the unnecessary size having been adopted in view of the possible future use of the plant in the electric lighting of the town. With apparatus more closely adapted to the work in point of capacity it is probable that the efficiency of the producers would be bettered 5 per cent., and that of the engines an equal amount with a resulting fuel consumption of about 1.08 lb. of coal per brake-horse-power hour, or a duty, allowing 80 per cent. efficiency of pump, of 146,000,000 ft.-lb. per 100 lb. of coal.

The work done in lifting water is equivalent to 13.4 per cent. of the mechanical equivalent of the heat units of the coal fired; the brake-horse-power developed by the engine to about 16.7 per cent. of the same figure.

The slip of the pumps was obtained in preliminary runs by pumping into the storage reservoir. In estimating duty the slip is charged against the engine and the larger slip of number one pump accounts for the lower duty obtained in this unit. The average duty for the three-day run, including banking and all stand-by losses, is 125,000,000 ft.-lb. per 100 lb. of coal, the fuel having a thermal value of 12,400 B.t.u. per pound and an ash content of 7.59 per cent. In considering this duty it is to be noted that the pumping units were of less than 2,000,000 gal. daily capacity, the head pumped against about 175 ft. and that the fires were banked for approximately 16 hours each day. The best results which might be expected from a steam plant of this capacity would not exceed 100,000,000 ft.-lb. per 1,000 lb. of steam based on a 10-hr. run and not over 85,000,000 ft.-lb. per 100 lb. of coal (13,000 B.t.u. per pound) used during the run.

A fair estimate of the coal used in banking such a plant would be 0.3 lb. of coal per hour per horse-power of boiler, or for a 100-h.p. boiler and a 16-hr. banking period 480 lb. per night. Including this in the daily fuel charge the station duty per 100 lb. of coal would be about 60,000,000 ft.-lb. or less than one-half that of the gas plant. With the steam coal available at the plant under discussion and containing not much over 10,000 B.t.u. per cubic foot, the station duty would be less than 50,000,000 ft-lb. That these figures are reasonable estimates of steam economy in a plant of this capacity is proved by a proposition submitted under the same general specification as that under which the gas plant was purchased and tested. Three bids were obtained and the duty guaranteed, including banking, varied from 40,000,000 to 65,000,000 ft.-lb. per 100 lb. of Nova Scotia coal. As the cost of this coal at St. Stephen is practically the same as pea anthracite there could be no doubt of the economic justification of the gas apparatus.

In any plant, except where the size permits the use of vertical, triple engines of the highest class, gas producers will demand less fuel expenditure than steam apparatus, but it is in pumping service where the fires are banked for a considerable period and particularly in equipments with capacities less than 5,000,000 gal. that gas plants make possible a pronounced saving in fuel. What this saving amounts to in dollars depends, of course, on the relative cost of steam and gas coal in any particular place. From Mr. Barbour's experience with this gas plant and in a considerable number of well-managed steam plants of various sizes, the fuel consumption with the gas apparatus will range from one-half to two-thirds of that required for the steam plants—the first figure applying to the smaller units and the last to the high-class horizontal, triplex or vertical compound engines. If compared with the lower grade of carelessly managed steam plants the relative economy is still more pronounced.



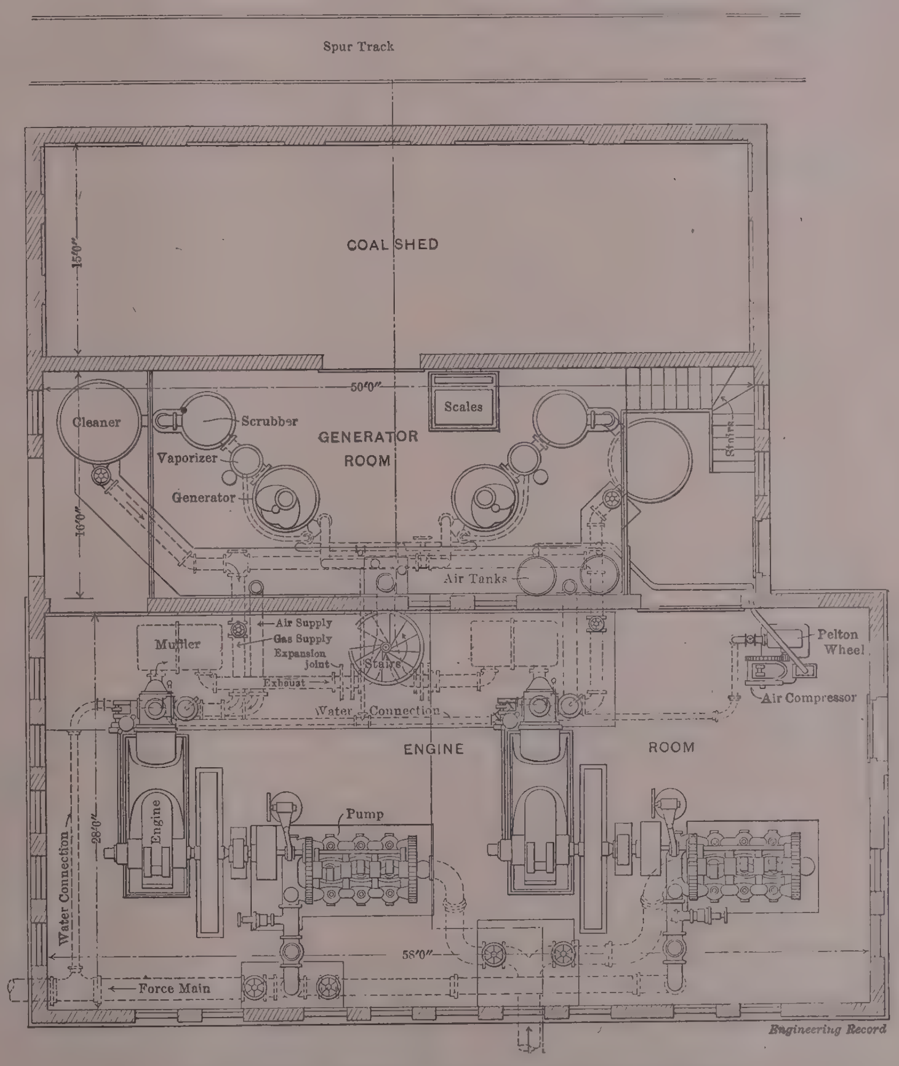
Details of the Muffler Water Heater.

As already stated, the small amount of fuel used in banking producers is noteworthy. During the test the average charge for a 16-hr. period was 22.5 lb., equal to about 0.01 lb. per hour per nominal horse-power of producer or three per cent. of the amount used in the twenty-four hours. In the regular operation of the station the banking charge, using American anthracite, is about double this amount, or 50 lb. per night. The necessary quantity depends upon the regulation of the draft, and by closing the producer tight the amount used in the test was reduced to a minimum. With such reduction, however, increased time is required when again starting up, to obtain suitable gas.

At times in the regular operation of the station both engines have been operated from one producer throwing about 150 b.h.p. on the single gas unit, equal to a brake-horse-power for each 0.21 cu. ft. of the capacity of the producer. Under these conditions the single producer will, for a time, supply both engines with a slightly less expenditure of fuel than when two producers are in use, but the higher temperature developed gradually induces excessive formation of clinkers, and it would appear that any demand in excess of the nominal capacity of producers, which is 0.25 cu. ft. per horse-power, constitutes an overload. During the test the average length of time required from the commencement of blowing hot to the time when the pump was running was 23 minutes. In every day operation the pumps are running within 30 minutes of the time when the engineer enters the plant.

The division of a plant into small units is of advantage in adapting the power to a variable load, or, in the case of a ground water supply, the varying draft of pump to the seasonal capacity of the supply. Such division can be effected in gas plants without loss of efficiency and perhaps with increased assurance of reliability.

The test herein described was designed to show what might be expected in daily operation, and it is of interest to note that in the eight months since the test was made, a station duty within 5 per cent. of that then obtained has been developed, although pumping against a lower head and using an inferior grade of American pea anthracite. In other words, the efficiency of a producer plant cannot be forced by expert handling during the test to the same degree possible with steam plants and the economy obtained in a 24-hr. test carried out under ordinary working conditions, and with the producer in regular operation several days in advance of the test, will give a fair expression of what may be continuously expected.



Plan of the St. Stephen Producer Gas Pumping Station.

The guarantee of duty at St. Stephen was based on coal having a thermal value of 13,000 B.t.u. per pound, with not to exceed 10 per cent. ash, nor 8 per cent volatile matter, nor 2 per cent. sulphur. The obtaining of such coal is not an easy matter, and that used in the test did not come up to these specifications in thermal capacity, although low in ash and better than American anthracite at the time available. The question of fuel for producers will demand considerable attention by those operating this type of plant. Apparatus for the employment of bituminous coal has not yet been sufficiently developed, according to Mr. Barbour, to justify its adoption; the gas obtained from coke is less rich than that from anthracite coal, and this latter fuel in pea size, for some time to come, will probably remain the most desirable material for producer work. The amount of incombustible material or ash, if not readily fusible, does not seriously interfere with the operation of the producer further than in increasing the labor of maintaining a free fire and in screening salvage. However, it indicates the probability of clinker formation in proportion to its amount, and a coal with low ash should be obtained if possible. Sulphur is an element to be avoided, and high volatile matters increase the possibility of dirty gas unless removed by burning in the producer or by condensation and elimination in the scrubber and cleaner.

It is difficult to obtain pea coal with less than 12 per cent. incombustible material. Analyses of samples recently collected at twelve different collieries show an average of 13.63 per cent. ash, with a minimum of 10.92 and a maximum of 20.65 per cent., and it would appear that future contracts should not be based on coal with an ash content lower than 14 per cent. Practically, the user of producer plants must buy commercial pea coal, as the mine agents will not sell according to specifications. If the coal is obtained from local wharves it usually contains, unless screened, so much sweepings and dirt that the ash will run well over 15 per cent. If specially screened it, of course, costs more than the average market price. The best way to obtain suitable coal is to buy direct from some colliery where the ash is reasonably low and sulphur is known, by anaylsis, to be not present in dangerous amounts.

In considering the advisability of a gas plant, the question of station heating demands attention. The utilization of the heat of the exhaust, amounting to from 30 to 40 per cent. of the total heat of the coal fired, at once suggests itself, and in St. Stephen this has been done by installing water-jacketed mufflers, of which a plan is herewith shown, through which the exhaust gases pass. Hot-water piping leads from these mufflers as from an ordinary heater, and to maintain the temperature when the plant is not in operation a small heater of the regular type has also been included in the heating equipment. Proper lubrication is difficult at low temperatures and some means of heating the engine room is necessary, as the heat from the engines is insufficient.

Mr. Barbour's experience indicates greater difficulty in maintaining an attractive engine room than in steamwork. Some gas will escape at times and some smoke from the cylinder lubrication—the first discoloring lead paints and metal surfaces, and the latter suggesting the advisability of high, well-ventilated ceilings. Lubrication is a larger item in the expense account than with steam apparatus, and in specifications emphasis should be laid on the means to be provided for preventing the throwing of oil from moving parts and for its collection after use.

The first cost of gas apparatus will be at least 20 per cent. greater than the cost of a steam apparatus of equal capacity, economically purchasable, but, as already pointed out, particularly in the smaller sizes the higher efficiency of the gas apparatus will more than make up for its increased first cost. The floor space required by the gas plant will not be less than that necessary for the steam apparatus, and the labor of attendance will be about the same in both plants. The first duty of a pump, entirely aside from its efficiency, is to pump water, and the question remains as to the relative reliability of gas and steam plants. By this term would be included the ability to start at a definate time each day without failure and to make the run without incident disturbing to the security of the service. A gas engine properly designed should be no more liable to mechanical accident than a steam engine, and with ignition difficulties discounted by reasonable care of the igniters and the cylinders and valves kept clean, prompt starting and steady running may be safely anticipated so long as gas of suitable quality is furnished by the producer. Specifications should require the furnishing of duplicate igniters, and if, when idle, the engine stands under conditions liable to condense moisture in the combustion chamber, a dry and clean igniter should be inserted before attempting to start. In the regular operation of the St. Stephen plant, however, the engine has been run for a month at a time without removing an igniter.

Difficulties in the running of gas plants may be charged to producer conditions, and usually to a failure to properly regulate the air and steam supply so as to maintain such a temperature that a gas of the proper calorific value will be developed. By intelligent supervision this can be done, although in the days of getting acquainted with the plant, many failures may result, and incidents perplexing and disturbing will await the novice in the work. The great need to-day is the development, by the manufacturers, of expert runners to put plants in operation and instruct the engineer who is to remain permanently in charge. At St. Stephen, in the month before the test was made, troublesome incidents frequently occurred.

After the test at St. Stephen, the plant was turned over to a local engineer—a steam engineer, but without prejudice—and up to the present time he has run the engines 8 hr. daily without trouble, starting up in less than thirty minutes and, as already stated, developing a duty within five per cent. of that obtained in the test.

In the face of this favorable experience, however, Mr. Barbour believes that it is not unfair to the gas plant to state that there are more factors, each essential to its operation, and one or more of which may for a short interval fail to do its work, than in the case of steam apparatus. A gas plant either works well and economically or not at all; a steam plant will usually run, but often at most extravagant cost.

As to the depreciation of gas apparatus there appears to be but little available information, but from general considerations it would seem that the temperatures and pressures involved in gas engine work must lead to a depreciation greater than in steam apparatus. Mr. Barbour's experience suggests the advisability of heavy, cast-iron piping in the exhaust line, a short section of wrought-iron having become honeycombed in the St. Stephen plant with a few months' work.

A producer plant requires closer attention during the hours of running than steam apparatus of the type usually employed. In a recent visit to one of the better class New England steam stations, Mr. Barbour found a 3,000,000 gal. compound vertical engine running with both engineer and fireman away at dinner in an adjoining house. Of course, this is not good practice, but certainly safer than in the case of a producer plant of equal capacity. There is also greater capacity in the steam apparatus to meet sudden changes of load as the producer must gradually accommodate itself to the change in order to maintain gas of uniform quality. With no storage a producer plant would not be the best power; for fire service and quick and absolute starting at full load it is not fitted, but, with an amount of water in storage sufficient to discount any reasonable delay or where the operation of the pumping plant has a not too intimate relation to the immediate supply of the consumer, the greater economy of the gas apparatus should give it precedence over steam in all cases, except those where circumstances justify the use of the highest class plants of the latter type.

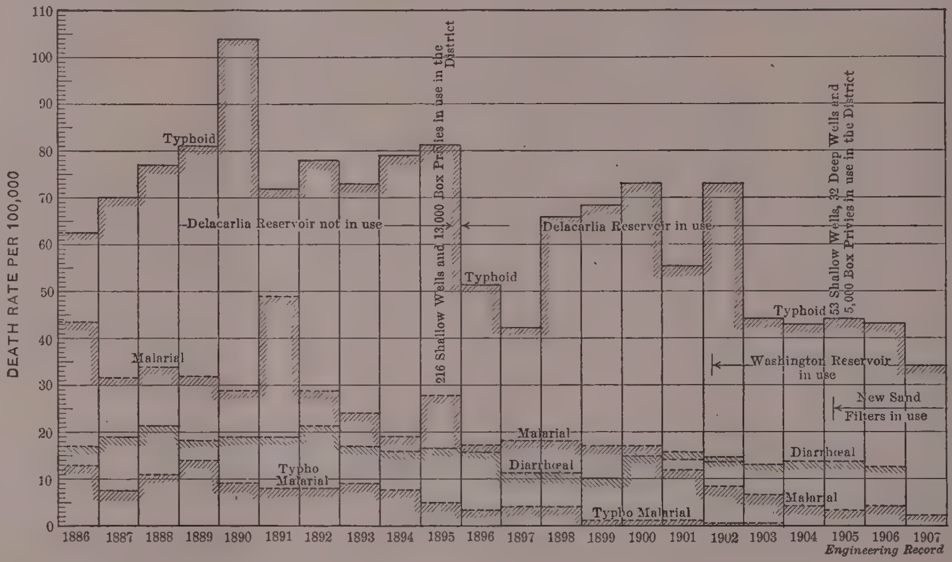
The Traffic on Prussian Inland Waterways is shown in a recent consular report to have been 52,753,019 metric tons in 1906, a large increase over that of the preceding year.

Conservation of Life and Health by Improved Water Supply.

Abstract of an address by George M. Kober, Professor of Hygiene, Georgetown University, presented at the Conference on Conservation of Natural Resources.

The water which is required for daily use comes from the clouds in the form of rain or snow. Of this a certain amount is evaporated; another portion may be collected in cisterns, another soaks into the earth to reappear in the form of springs, another portion flows off in the direction of surface slope to join the ponds, lakes, streams or rivers, or it may penetrate the earth sufficiently deep to require us to dig wells for its collection. The sources of domestic water supply may therefore be classified as rain and snow water, surface water (including ponds, lakes, streams and rivers), and ground water including springs and wells

The amount of water available for community purposes depends on the precipitation and the precautions taken in a given watershed for the conservation of the waters. The mean annual rainfall for different portions of the United States has been tabulated by the United States Weather Bureau; it averages some 30 in.



Effect of Water Purification on Various Death Rates in Washington, D. C.

Fanning gives the average of 40 in. for New England and the Middle States. One inch of rain would amount, according to Church, to nearly 101 (gross) tons per acre or on a house roof of say 20 x 20 ft. area, 1 in. of rain would be about 250 gal. With a rainfall of 40 in. per annum this would amount to 10,000 gal., or 27 gal. per day. The average daily supply per capita in most of our Northern cities ranges from 20 to 127 gal., or more.

The needs for community water supplies are met according to the location of the town or city with reference to the availability of springs, streams, rivers and lakes. Since springs rarely yield a sufficient supply of water for general use, it is perfectly natural that in the majority of instances, surface water, like streams, rivers, lakes or ponds were utilized for public water works and when these were not available, recourse was had to shallow and deep wells and so-called filter galleries.

It is interesting to note that according to M. N. Baker the number of towns in this country before 1800 having a public water supply was only 16, supplying about 2.8 per cent. of the existing population; in 1850 there were only 83 public waterworks, supplying about 10.6 per cent. of the census population; in 1897 the total number was 3,196 supplying about 41.6 per cent. of the population. The number has greatly increased, but exact information is not available.

River water is a mixture of spring, ground, rain and surface water. The English River Pollution Commission in its Sixth Report, estimated that about one half of the water descending as rain finds its way into streams. Rivers are always purer near their source; the amount of impurities increases as we descend the stream, since the water-courses are the natural drainage channels of the country and the wastes of human life and occupation find their way into the streams. It is for this reason that rivers, after passing through cultivated valleys with cities, towns or settlements along their banks often contain a dangerous amount of mineral and organic matter. Thus the Mississippi at Minneapolis contains only 18.6 total solids per 100,000, while the same river at St. Louis contains 244.3 per 100,000.

The sanitarian recognizes two principal forms of pollution; first, the amount of mineral matter, and second the character and amount of organic matter contained in the water. The amount of mineral matter depends largely on the geological formation of the country and the erosive power of the streams. Water containing 50 parts per 100,000, or 30 grains of solid matter per gallon is unfit for drinking purposes on account of its irritating effects upon the gastro-intestinal tract; but beyond this, turbidity is of no special sanitary significance unless the water also contains metallic poisons or objectionable chemicals.

The Potomac River, which may serve as a type of American rivers for our discussion, is subject to various forms of pollution. For example, certain pulp mills, tanneries and manufacturing establishments defile the water by chemicals and other refuse—one paper mill alone discharges over 100,000 gal. of liquid into the river each day heavily laden with sulphuric and tannic acids.

These forms of pollution, although at times so great as to prove destructive to game fish, are of less interest to the sanitarian than contamination with excrementitious matter from human beings or animals, within the towns and settlements of the Potomac basin; the drainage area of the river covers 11,400 square miles, with a population of 501,647 or 44 per square mile. Among the larger towns may be mentioned Cumberland, Frederick, Hagerstown, Harpers Ferry, Staunton; as none of these are wholly sewered, most of the contamination is derived from surface drainage.

Notwithstanding these numerous sources of pollution, the Potomac River, according to the chemical analysis, compares very favorably as regards purity with other American rivers. The results arranged in Table 1 for comparison are based on daily analyses of the Potomac water made by Mr. R. S. Weston, between July 1, 1899, and Jan. 20, 1900, and daily analyses made by Mr. F. F. Longley in 1906 and 1907.

Table 1.—Results of Analyses of Potomac Water.

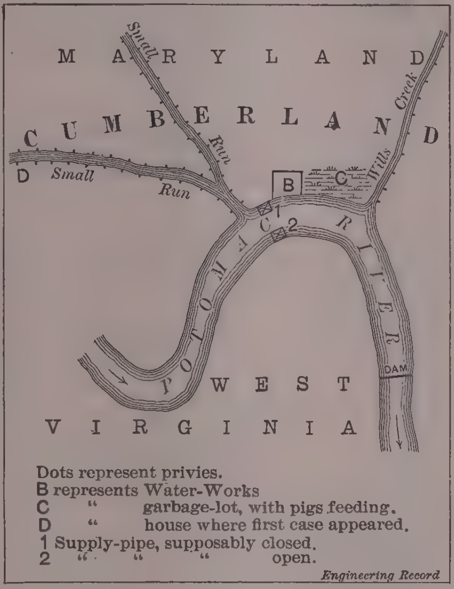
	Total solids.	Free ammonia.	Alb. ammonia.	Nitrites.	Nitrates.	Chlorine.	Required oxygen.
Robert S. Weston	139.0	0.013	0.105	0.002	0.73	2.60	4.50
F. F. Longley (*)	....	0.013	0.075	0.088	0.0035	1.70	
" " (†)	....	0.015	0.075	0.093	0.0037	1.80	
Mason's safe limit	150-300	.01-.12	.10-.28	.0135-.033	0.42	3.10	5-7

(*) Average for 1906. Turbidity 142.
(†) Average for 1907. Turbidity 97.

Bacteriological examinations of this water have been made by various competent authorities at the Army Medical Museum, and by Kinyoun and and Sprague, of the Public Health and Marine Hospital laboratory. The latter also examined samples at or near all the important towns from the head waters of the Potomac and Shenandoah. These samples may be said to accurately represent the bacteriological conditions of the entire river, and intestinal organisms were found in over 50 per cent. of the specimens examined. The more recent examinations conducted by Mr. F. F. Longley, chief chemist of the Washington Filtration Plant, show that of 906 samples tested, 45 per cent. revealed the presence of the *bacillus coli communis* which belongs to the sewage group. The germs are always more plentiful during colder months, because of the fact that in winter much water runs in over the surface from manured fields and the purifying agencies are less active.

These exhaustive studies also confirmed the conclusions of Theobald Smith and the writer, that turbidity of the Potomac water is always accompanied by a larger amount of organic matter and germs, and that fecal bacteria and turbidity are coincident, simply because the same showers that bring along large sections of pulverized river banks, also wash through towns, barnyards, cesspools and outhouses before finding their way into the creeks and rivers. Mr. Longley's examinations covering a period of 27 months show that a wave of high turbidity is always accompanied by a very high bacterial content, the maximum number of bacteria per cubic content in the raw water was 175,000 during a period of highest turbidity; the minimum number per cubic content was less than 100 during a period of lowest turbidity, with an average during the entire period of 4,852.

The presence of intestinal bacteria is satisfactory evidence of contamination with fecal matter of man or animals. Apart from the fact, that it conclusively shows, that much valuable organic matter has been carried away which should have been retained in the uplands for manurial purposes, the presence of sewage bacteria is significant of danger and strongly points to the possibility that such waters may be infected with typhoid bacilli.



Vicinity of Cumberland, Md.

It has been estimated that the sewage from the vicinity of Cumberland, a distance of about 134 miles, requires from two to four days to reach the Washington Aqueduct. It is also known that typhoid germs retain their vitality in ordinary water from six to ten days, and could therefore infect consumers of water in Washington.

Dr. Kober's suspicions that typhoid fever germs may travel all the way from Cumberland were confirmed as early as the winter of 1889-1890, by studying the effects of the typhoid fever epidemic at Cumberland upon the prevalence of the disease in Washington. The records of the Health Office show that during this epidemic, from December, 1889, to April, 1890, the deaths from typhoid fever amounted to 74, as compared with 42 for the corresponding months of the previous year. Indeed, almost double the number of typhoid deaths occurred during these months than for any similar period either before or since this epidemic.

The accompanying chart shows that this epidemic resulted in the highest typhoid mortality rate ever reached in this city, viz., 104 per 100,000, as shown in Diagram 1.

Cumberland during these four months had 45 deaths and 485 cases, Washington had 74 deaths and about 740 cases, and yet the starting point was the excreta of one patient washed into a little run, which empties into the Potomac about 300 ft. above the pumping station of the water supply for Cumberland. In the face of this fact, and the almost constant presence of intestinal bacteria, Dr. Kober had no hesitation in declaring that a considerable proportion of typhoid fever in the National Capital was due to infected Potomac water, and with other members of the medical profession urged its purification.

The accompanying Diagram 2 shows conclusively that the typhoid fever rates were highest when the Potomac water was served in a raw state without any preliminary purification whatever.

The Dalecarlia Reservoir was not in use as a sedimentary basin from June 20, 1886, to July 28, 1895. The comparatively high typhoid fever rates, especially during the Cumberland epidemic which started in December, 1889, are evident. The decline, especially after the installation of the McMillan Reservoir in 1902, may also be seen. The sharp rise in 1902, in the light of knowledge of bacillus carriers, may possibly be explained by the assumption that during the construction of the tunnel and reservoir more or less pollution took place by careless workmen.

The diagram is also instructive in showing a remarkable decline in the deaths from malarial and typho-malarial fevers and diarrhœal diseases. There is little doubt that many of these cases were really typhoid fever, and that the decrease in typhoid fever is, in fact, very much greater than appears from the mortality returns.

When the fact that deposition of sediment alone removes 87 per cent. of the bacteria in a local water system is recalled, it is readily appreciated what Professor Sedgwick has said "that the purifying effect of these sedimentary basins was immediately to remove from the polluted river water a large percentage of any typhoid fever germs present at the intake, and thus to forestall to a remarkable and unforeseen extent the burden of removal which the filter was expected to bear." It should also be borne in mind that during the year 1906 typhoid fever prevailed in Cumberland to an unusual extent, but contrary to the experience of 1890, there was no increase; hence it may be fairly presumed that the filtration plant, as expressed by Dr. Magruder, "stood as a guard between the inhabitants of Washington and Cumberland." The typhoid rate in 1907 was only 34.59 per 100,000, which is the lowest rate ever reached, and certainly a remarkable reduction from 104 in 1890.

What has been said of the Potomac River is equally applicable to the Ohio, Mississippi, Merrimac, Connecticut, Missouri and other American rivers, because they are the sewers and at the same time the source of water supply for nearly all the cities located on their banks. These cities show, moreover, a marked prevalence of typhoid fever, thus confirming what has been observed over and over again, that this disease, as also cholera, dysentery and diarrhœal diseases can be carried from one town or city to another by means of inland waterways. Indeed, the question is one of extreme interest even to the residents along the Great Lakes, the basin of which according to the census statistics (especially the area contiguous to Lakes Ontario, Erie and Michigan), is next to the Atlantic seaboard the most densely populated area of the United States; we know that large cities like Buffalo, Erie, Cleveland, Detroit, and Milwaukee discharge their sewage into the lakes, and it is known how Chicago and Cleveland suffered from typhoid fever visitations by contaminating their own water supplies. It is also a well-known fact that many of the river cities were obliged to resort to purification of their water supplies in order to arrest the ever increasing typhoid fever wave.

For the purpose of determining the influence of public water supplies on the typhoid fever death-rates in general, Mr. M. O. Leighton, chief of the Water Resources Branch of the U. S. Geological Survey, complied with Dr. Kober's request for a list of the principal American cities with a population of over 30,000, classified according to the sources of their water supply. Dr. Cressy L. Wilbur, chief statistician of vital statistics, Bureau of the Census, furnished the death rates from typhoid fever for the calendar years 1900 to 1906 inclusive, these being all of the years for which annual returns of deaths have been received by his office.

In order to give a general view of the relative death rates, Dr. Wilbur has computed the mean rate (not the average annual rate, which, however, differs only slightly for the five years 1902 to 1906), and has arranged them in Diagram 3, given herewith. It has been necessary to omit certain cities either because the information supplied was not of an entirely definite character, or because the city was not accepted as a registration area for the whole or a part of the period covered. This diagram is also restricted to cities in which, according to the information supplied, there has been no special means of purification during the period covered.

Detail statistics regarding the various cities in this country were given in a long table accompanying the report, from which a summary of typhoid fever death rates is given in Table 2. The rates for cities using unpurified river water fluctuate from 33.1 at Minneapolis to 122.1 at Allegheny and even 133.1 at Pittsburg.

Table 2.—Mean Typhoid Fever Death Rate from 1902 to 1906 per 100,000 of Population.

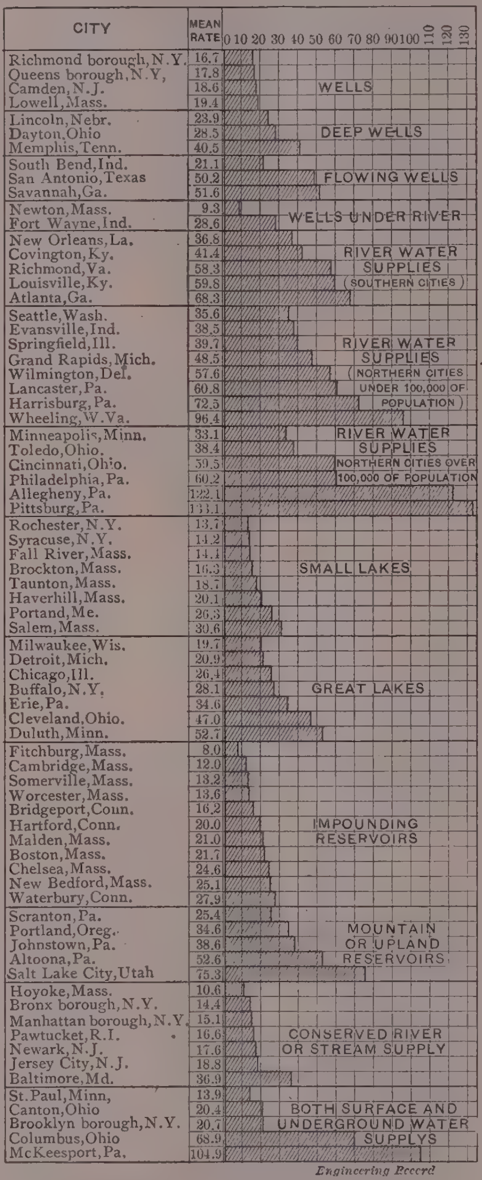
4	Cities using ground water from large wells	18.1
18	" " impounded and conserved rivers or streams	18.5
8	Cities using water from small lakes	19.3
7	" " " " the Great Lakes	32.8
5	" " both surface and underground water	45.7
19	" " Polluted River Water	61.1

Water pollution involves both economic and public health problems. Victor Hugo claimed that Paris casts 25 millions of francs annually into the sea. While it is true that the sewers of Paris discharge daily not less than 300,000 cubic meters of sewage into the River Seine, which before the establishment of sewage farms was lost to the agriculturist, its actual value has been overstated by this brilliant author.

Von Pettenkofer calculates the average amount of feces per annum at 34 kgr. and of urine 428 kgr. for each person. Fresh feces contain on the average 25 per cent. of dry solids with about 1.4 per cent. of nitrogen, while fresh urine contains from 4 to 5 per cent. of solids, with about 1.33 per cent. of nitrogen. Erismann calculates that the refuse of a city of 100,000 inhabitants amounts every 24 hours to 9 cubic meter of feces, 120 cubic meters of urine and 12,500 cubic meters of house waste waters; he does not include the sweepings. Uffelmann estimates these at 140 cubic meters, or a total of 12,768 cubic meters a day, exclusive of the rainfall.

The estimated money value of the refuse of a city of 100,000 upon the above basis is stated by Paltzow and Abendroth to be not less than 3,600,000 marks, or about $900,000 per annum, but these values, although conservative for German conditions, are quite theoretical and will depend largely upon the demand.

According to the Census of 1900 there were 35,379 deaths from typhoid fever during the census year throughout the United States; and based on an estimated mortality of 10 per cent., it is within reason to assume a yearly prevalence of 353,790 cases of this disease. Assuming the average cost for care, treatment and loss of work to be $300 and the average value of a human life at $5,000, a total loss in the United States of $283,032,000 occurs from one of the so-called preventable diseases. Mr. George C. Whipple, in a discussion of the value of pure water, presents some striking evidence to indicate that a loss of $10,000 for every death from typhoid fever is a conservative estimate, in which case the decrease in the "vital assets" during the census year of 1900, would amount to $353,790,000. Reduce the prevalence of this disease one half (which has been accomplished in Europe and this country), and the economic question of the hygienic value of pure water will be answered.

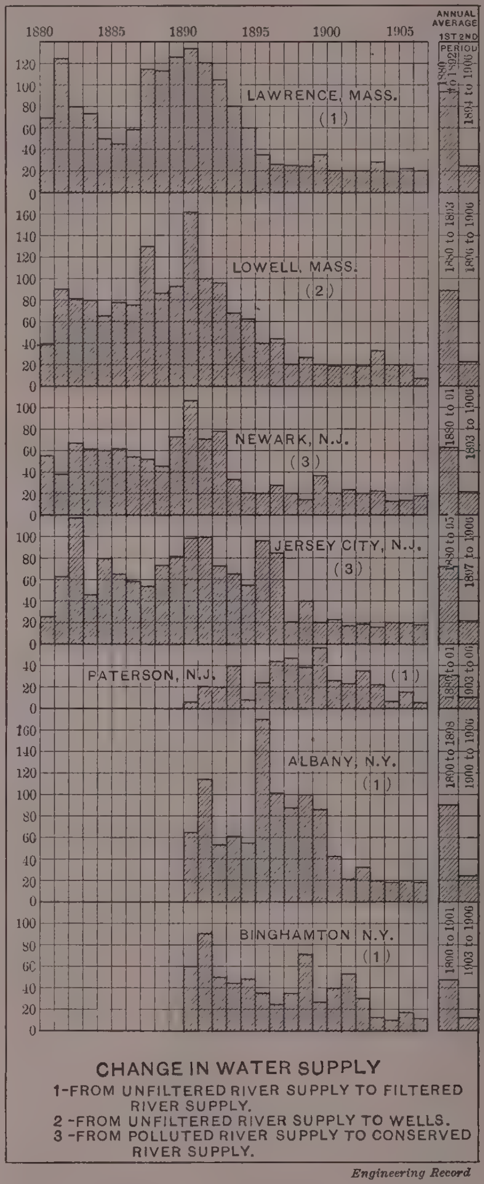


Typhoid Deaths per 100,000 for 1902-1906.

Mr. Whipple, while admitting that this is merely a transference of money from one man's pocket to another, emphasizes the fact that "unnecessary expenditure is a loss," and that deaths from typhoid fever and from other diseases represent a very material loss of the productive capacity of a community and consequently a decrease in what may be termed the "vital assets." He computes upon what may be regarded a very sound basis, that "each million gallons of polluted Allegheny River water pumped into Pittsburg has heretofore reduced the vital assets of the community by $110. This for a population of 350,000 amounts to $3,850,000 per year—a sum enormously greater than the annual cost of making the water pure."

In like manner he calculates that the increased value of the water to the city of Albany, where the typhoid fever rate was reduced from 104 to 26 per 100,000 by efficient filtration amounts to $475,000 per year, of which at least $350,000 may be considered as a real increase in the vital assets of the city."

The effect of change of water supply on typhoid fever death rates in seven American cities is shown in Diagram 4, based on a long table accompanying the address. Dr. Wilbur, of the Bureau of the Census, has given the death rate for a considerable time before and after the date of change, and also the average annual death rate before and after purification, and the percentage of reduction. From the table it was shown that the combined average annual death rate from typhoid fever in cities with a contaminated supply was 69.4 and after the substitution of a pure supply it fell to 19.8 per 100,000; a reduction of 70.5 per cent.



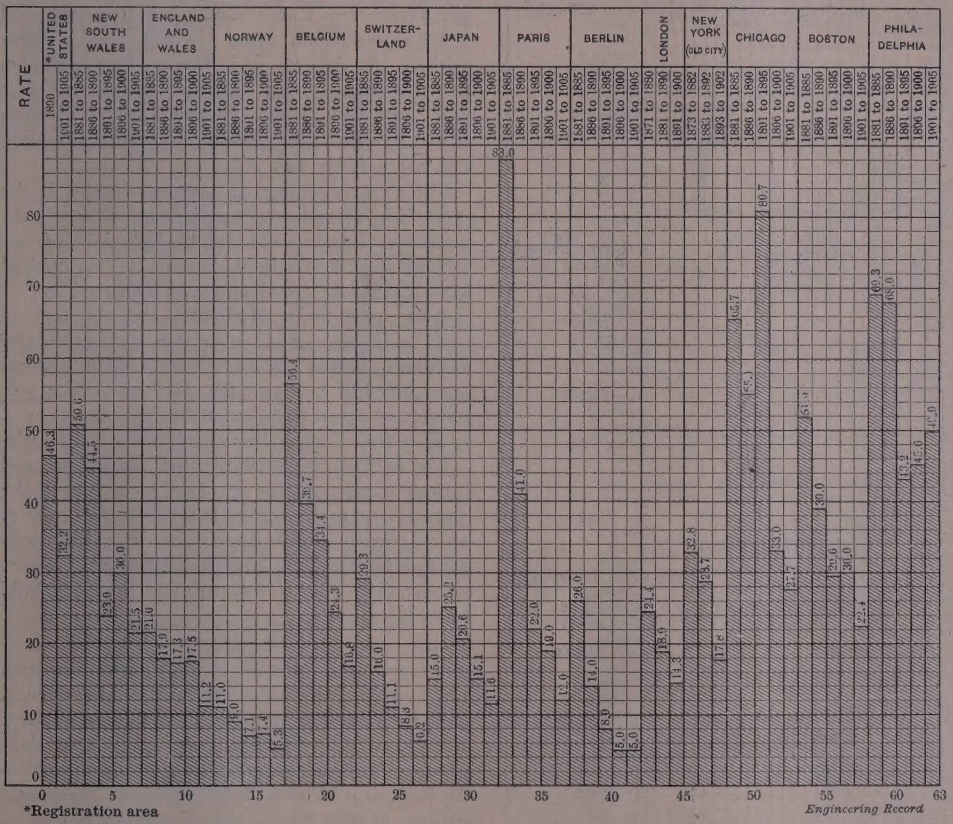
Typhoid Deaths per 100,000 in Seven Cities.

The Bulletin for the month of April, 1908, of the New York State Department of Health contains an interesting article showing that the death rate from typhoid fever in ten cities of that State has been reduced 53.4 per cent. by an improved water supply. The details are shown in the accompanying Table 3.

It may be urged that improved methods of medical treatment are responsible for a considerable reduction in the death rates from typhoid fever, but when in the light of such a striking change immediately after the installation of fitration plants as in the case of the American cities shown in Diagram 5, the conclusion may be drawn that water purification plays the most important role. The rates in this chart are per 100,000 of population, except in the case of the city of Cincinnati, where a comparison is made in the number of deaths since the introduction of filtered water, for November and December, 1907, January, February and March, 1908, and the corresponding months for 1905, 1906 and 1907.

TABLE 3.—REDUCTION IN AVERAGE TYPHOID DEATH RATE PER 100,000 DUE TO CHANGE IN WATER SUPPLY.

Cities in New York State.	Average before improvement.	Average after improvement.	Per cent. reduction in death rate.
Albany	88.8	23.7	73.0
Binghamton	39.3	11.7	72.2
Elmira	54.9	41.5	24.4
Hornell	42.2	24.7	41.4
Hudson	64.3	31.9	50.5
Ithaca	67.2	14.6	78.3
Rensselaer	95.5	54.4	43.0
Schenectady	25.0	14.4	42.6
Troy	58.2	31.0	46.8
Watertown	94.7	36.9	61.8



*Registration area

Typhoid Fever Death Rates per 100,000 for Various Countries and Cities.

The general movement of typhoid fever in different countries and cities showing percentage of decrease from first to last period were shown in another long table accompanying the report, and are graphically illustrated herewith in Diagram 6. The period covered by Dr. Wilbur is (as nearly as convenient) the last quarter of a century, and the rates are usually given for successive five-year periods, beginning with 1881. The table showed that during the last 25 years the death rate from typhoid fever has fallen in 14 countries and cities from an average of 42.3 to 18.1 per 100,000, a reduction of 54.3 per cent. A more striking reduction could have been made, if statistics going back as far as 1870 had been included. The typhoid rate in Berlin in 1872 at a time when that city was riddled with cesspools and supplied with polluted water was as high as 142 per 100,000. On account of the incomplete mortality returns everywhere prior to 1881, it was deemed to exclude all older foreign statistics, and for similar reasons Dr. Wilbur begins his statistics for the United States with 1890. Mr. Whipple's statistics, which tend to show that the death rate from typhoid fever in 12 States, including all of the New England States, New York, New Jersey, Maryland, California, Minnesota and Michigan, has fallen from 55 in 1880 to 21 per 100,000 in 1905, were also excluded.

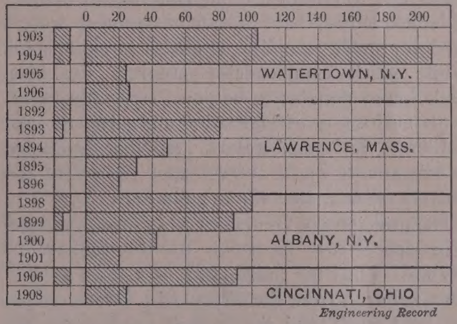
The incomplete and unsatisfactory character of the mortality statistics in the United States is largely due to the limited extent of the registration area. The importance of vital statistics, which constitute the foundation stone of public hygiene, is not fully recognized by our States, and yet, as remarked by Dr. Billings, "when we wish to study the healthfulness of a city, whether it is getting better or worse, or judge correctly the effect of certain sanitary laws, we should not only know the number of deaths, but also the amount and character of the prevalent diseases together with accurate information as to the number of population at different ages."

What has been said of typhoid fever is equally true of other water-borne diseases like cholera, dysentary, cholera morbus, diarrhœal diseases and the transmission of the eggs of intestinal and other parasites, because the germs or eggs of these diseases are present in the intestinal tract and presumably also in sewage contaminated water. Thus, for example, the cholera epidemic of Hamburg in August, 1892, resulting in 17,020 cases, with 8,605 deaths, was caused by a band of gypsies camped on the banks of the river Elba, and the discharges of one of its members suffering from cholera were emptied into the river which at that time was served to the inhabitants of Hamburg without filtration. The epidemic spared the adjoining city of Altona, which derives its water from the same river after receiving the sewage of Hamburg with its 800,000 people, but Altona filtered its water and Hamburg at that time did not.

What the purification of Potomac water has accomplished in the way of reducing the mortality from typhoid, malarial and diarrhœal diseases, Mr. Allen Hazen has conclusively shown that as a result of the installation of filtration plants in five cities supplied previously with an impure water, there was not only a reduction of 81 per cent. in the deaths from typhoid fever, but also a marked reduction in the general death rate. His computations clearly indicate that where one death from typhoid fever has been avoided by the use of a better water, a certain number of deaths, probably two or three from other causes have been avoided. It is a difficult matter to explain how water is connected with the deaths other than those from water-borne diseases, yet when it is considered that water enters into the composition of the human body to the extent of 63 per cent., one may appreciate the sanitary acumen of Aristotle when he wrote in his Politica: "The greatest influence on health is exerted by those things which we most freely and frequently require for our existence, and this is especially true of water and air."

Professor Finkelnburg, of Bonn, estimates that the average length of human life in the sixteenth century was only between 18 and 20 years, and that at the close of the eighteenth century it was a little over 30 years, while to-day it is between 38 and 40 years—indeed the span of life since 1880 has been lengthened about six years. No two factors have contributed so much to the general result as the improvement of the air we breathe and the water we drink. Indeed, ample evidence is available that with the introduction of public water supplies and sewers the general mortality in numerous cities during the past fifty years has been reduced fully one-half, the good effects being especially shown by a marked decrease in the number of cases of typhoid fever, diarrhœal diseases, and consumption. The vital statistics of Great Britain furnish the proof, and experience with American cities confirms this conclusion.

The mortality of London between 1660 and 1679 was 50 per 1,000 of inhabitants; from 1680 to 1728, including the period of pests, it was 80 per 1,000; between 1729 and 1780 it was still 40 per 1,000, since which time it has steadily decreased to 15.1 per 1,000 in 1905.



Reduction in Death Rates Incident to Water Purification.

The death rate in the City of Berlin has been reduced from 32.9 in 1875 to 16.4 in 1904; in Munich from 41.6 in 1871 to 18 in 1906, and in Washington from 28.08 in 1875 to 19.25 in 1907.

The death rate in the city of New York in 1804 was 28 per 1,000; from 1850 to 1854 it was 38 per 1,000; while in 1906 in spite of the density of population it was 18.9 per 1,000, practically a reduction of 50 per cent., which, according to Mr. Walter F. Wilcox, of Cornell University, means a saving of something like 46,000 lives each year in that city alone.

The mortality in the registration area in the United States has been reduced since 1890 from 19.6 to 16.2 per 1,000 in 1905. Taking the census figures of a population of 33,757,811 in the registration area as a basis, the number of deaths in 1905 was 544,533; whereas at a rate prevalent in 1890, they would have been 662,654; a reduction of 17.8 per cent. and a saving in one year of 118,121 lives. If the same ratio is applied to the entire estimated population in the United States of 82,574,195 the saving of human lives during 1905 alone would be over 290,000.

None would think of establishing a vicious circle between our mouths and the drainage of our houses and stables, and yet practically this has been suffered to be done upon the assumption that rivers purify themselves. A certain degree of purification is possible by natural means, such as dilution with unpolluted water, deposition of suspended matter, the agency of aquatic animals and plants, the bacteria of nitrification, the destructive influence of sunlight upon germ life, and the chemical affinity of certain bodies. These factors are calculated to purify waters, provided a chance is given them. This may still be true in very sparsely populated regions of this country, but with increasing settlements, the pollution of our streams will become continuous from their sources to their mouths, and river water to which sewage gains access must be considered as dangerous for drinking purposes.

One of the most pressing needs is an investigation into the pollution of water supplies, when such pollution affects or threatens to affect the sanitary condition of the people of more than one State, because the individual States are powerless to protect themselves against the misdeeds of their neighbors. Mr. Bartholdt's bill for the appointment of a river pollution commission, first introduced in 1896, has not yet become a law. England enjoyed the benefit of such a commission as early as 1855, and in order to prevent, remedy and remove the danger of polluted water supplies, adopted a comprehensive system for the disposal of sewage and of water purification, the fruits of which have already been referred to.

Sanitarians have maintained for years that no community or individual has a right to pollute streams used for public water supplies any more than a man has to poison his neighbor's well. The legal aspects of Water Pollution were presented by Dr. J. L. Leal in a paper read before the American Public Health Association, 1901, and it is gratifying to note that quite a number of our States and Territories, though in various degrees of effectiveness, have sought to protect waters used for public supplies within their boundaries. While much commendable progress has been made, more remains to be done, especially as regards uniformity of legislation and adequate protection of interstate waters. All that is needed in this country is a correct appreciation of the dangers of interstate water pollution.

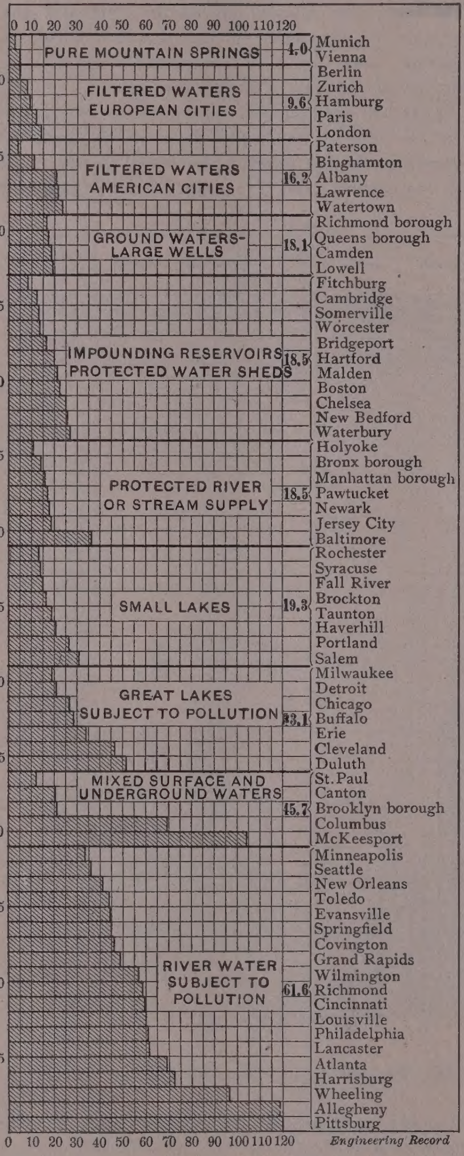
The principles of common law as to waters have been appreciated by some of the nations of Europe. Thus the inhabitants of a town in Belgium suffered from the effects of a river polluted by the French, and the French government not only compelled the offending city to dispose of its sewage by irrigation, but granted a subsidy for this purpose.

After determining the extent and dangers of river pollution, the remedy can and should be applied. This remedy is not only of interest to the sanitarian but also the agriculturist and consists in the adoption of a proper method of sewage disposal, including harmful industrial wastes.

The best methods so far proposed, Dr. Kober says, is sewage farming or irrigation. The British Royal Commission as early as 1876 approved it; in fact, this method has been successfully used for centuries on the hot plains of Northern Italy and in Spain, and will also have a very promising future in the West where every drop of water is needed for irrigation.

The city of Berlin purchased about 20,000 acres of land, and notwithstanding the enormous outlay of a little over $3,000,000 for the land and over $10,000,000 for the sewer system, operates these farms at a net profit of about $60,000 per annum. The city employs men condemned to the workhouse as laborers at the farms, and practically converts vagabonds into a producing class, with a fair prospect that many of these individuals will continue their honest efforts to become self-supporting citizens. Moreover, the old manor houses of the individual farms are utilized as country homes for convalescents, and thus the beneficient effects of this system are felt in more than one direction.

Heretofore it has not been considered necessary to prevent the pollution of rivers affected by tide waters. Dr. Conn, of the Wesleyan University, in 1894, traced, however, an outbreak of typhoid fever to raw oysters, which had been fattened in a place where they were liable to contamination by typhoid infected sewage, and since then numerous instances have been reported elsewhere. It has been shown that typhoid fever germs remain viable in oysters from fourteen to thirty days, and the medical officer of the local government of England, in the twenty-fourth annual report, points out the danger of many of the oyster beds from the sewage pollution on the English coast, all of which indicates that even this newly discovered source of danger must be properly guarded against.



Engineering Record

Typhoid Rates According to Water Supply.

On the whole, Dr. Kober believes it may be concluded that sewage farming for economic reasons should be recommended for all localities where the grade will admit of the sewage being carried to lower lands. In sections of this country not adapted to farming and where land is scarce and expensive, purification of sewage by intermittent filtration should be adopted; in communities where land is so scarce that even intermittent filtration is impracticable chemical precipitation or sedimentation; the bacterial or septic tank with Dilden's bacteria filters should also be considered.

It is a matter of great satisfaction to know that within the past 15 years over one hunderd communities in the United States have established plants for the disposal of sewage. In 1901 Dr. Kober published a tabulated list of 93 communities. In 1904 Mr. Geo. W. Fuller published a list of 114 towns and cities of over 3,000 population. A summary of the different types of sewage purification is given in Table 4:

TABLE 4.—SUMMARY OF TYPES OF SEWAGE PURIFICATION.

	Number of plants.	Estimated population.
Irrigation	14	200,000
Intermittent sand filtration	41	250,000
Chemical precipitation	8	320,000
Chemical treatment by Power's Patent	5	125,000
Sedimentation (including grit chambers and receiving basins)	3	8,000
Strainers or roughing filters	4	20,000
Coarse grained filters at high rates	10	95,000
Septic treatment	29	160.000
	114	1,178,000

The first attempt in the establishment of a sewage farm in this country was made at the Augusta (Me.) State Insane Asylum in 1872. Among the more prominent and successful sewage farms Dr. Kober mentioned Brockton and South Framingham, Mass.; Bristol, Conn.; Plainfield, N. J.; Altoona and Wayne, Pa.; Pullman, Ill.; Hastings, Neb.; Colorado Springs, Colo.; Salt Lake City, Utah; Helena, Mont.; Phœnix, Ariz.; Fresno, Los Angeles, Pasadena, Redding and Santa Rosa, Cal.

The primary object of sewage disposal is the prevention of water-borne diseases, although the economic aspect should not be lost sight of, especially since it has been shown that this method alone cannot be relied upon, as instanced by the cholera epidemic at Hamburg, and the typhoid fever epidemics at Cumberland, Plymouth and elsewhere, where the dejecta of a single patient were sufficient to cause the mischief; hence prevention of river pollution must be supplemented by filtration of the water supply on a large scale.

The relation between typhoid death-rates and various water supplies, grouped according to the character of their source, is given in Diagram 7, which shows conclusively that the European cities, who not only prevent pollution of rivers but also filter their water, enjoy the lowest typhoid fever rates.

A LARGE IRRIGATION PUMPING STATION has been built on an island at Divi, Madras Presidency, India, to supply water to an ultimate development of 80,000 acres. The equipment consists of eight 39-in. centrifugal pumps, each direct-connected to 160-h.-p. two-cylinder Diesel engines. The pumps operate at 180 r.p.m. and discharge 73 cu. ft. per second with a lift of 12 ft. Two 9-h.-p. engines operate two plunger pumps for pumping the liquid fuel, two pumps for cooling water and two vacuum pumps for filling the main pumps. The liquid fuel is brought from Madras, 225 miles by rail and 42 miles by canal and river, and is stored in two steel tanks having a total capacity of 269 tons. The engines are supplied by gravity from a service reservoir on the roof, the reservoir being filled from the storage tanks by the auxiliary pumps. The area irrigated is now developed to the extent of 50,000 acres. It lies so low that heavy banks were necessary to prevent destruction by the excessively heavy floods, which at certain seasons had formerly submerged the island. The supply channel from the river has sluice gates at two levels, the lower level gates leading to the suction culverts under the pump room and the higher level gates directly to the main distributing canals. The lower gates are used in the dry season when pumping is necessary, and the upper gates during the flood season, when irrigation is by gravity. The subsoil was quite soft and it was necessary to found the engine house on a solid block of masonry in order to carry the heavy machinery with safety.

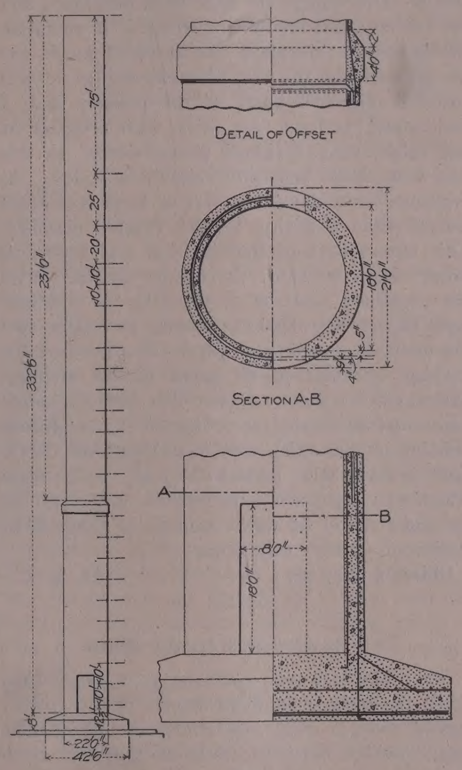
A Tall Concrete Smelter Chimney.

In an article referring to the arrangement of waste-heat boilers at the smelting plant of the Colusa-Parrott Mining & Smelting Co., at Butte, Mont., that was published in The Engineering Record for July 6, 1907, reference was made to a tall concrete chimney that had been built for the operation of these boilers in connection with a long settling chamber. This chimney is of interest in that the gases handled, while of low temperature are corrosive, and that it stands on a foundation of slag from the smelters. The chimney was built to serve a group of three copper-matte furnaces, which were formerly operated with tall steel stacks. As these furnaces were later fitted with waste-heat boilers for reclaiming a portion of the heat of the waste gases, a taller stack became necessary to produce draft sufficient for their satisfactory operation. With the present arrangement, the furnaces discharge their gases through the waste-heat boilers to a brick flue, about 12 x 14 ft. in section, which is elevated over the slag tracks and 16 ft. distant from the tapping holes. This flue is in turn connected to the stack through a large settling chamber, which is about 50 ft. wide, 19 ft. high inside and several hundred feet in length, for the purpose of effecting the settlement of the metal-bearing dust that would otherwise be carried to waste out of the chimney, but is, by reason of its settlement and reclamation, the source of considerable additional revenue to the company. With the low temperature of the issuing gases thus caused, the gases leaving the waste-heat boilers at a temperature of not over 500 deg. Fahr., it was necessary to erect a tall chimney in order to provide sufficient draft for the furnaces, as well as also to deliver the corrosive fumes at such an elevation as to minimize their effect on the surrounding community and on vegetation in the vicinity. For the latter purposes a 350-ft. concrete chimney, with 18 ft. inside diameter, was designed and erected for the smelting company by the Weber Steel-Concrete Chimney Co., now The Weber Co., of Chicago, Ill., which chimney is one of the tallest that has been built of this construction.

The chimney follows in general form the usual Weber practice, consisting of a lower straight cylindrical shell resting on a square base, with an offset at the top of the lining course, above which it rises as a straight cylinder of slightly diminished diameter to the top. The lower section, which is 101½ ft. in height from the top of the base to the top of the offset, is a shell 21 ft. in outside diameter and 9 in. in thickness, within which there is a 5-in. lining shell that is separated from the outer shell by a 4-in. air space. The upper section, which is 231 ft. in height above the top of the offset, has a wall thickness of 7 in., and overhangs the lining course so that its bore is in line with that of the lining shell. The chimney has, in the lower section immediately above the base, two flue openings on opposite sides, each 8 ft. wide by 18 ft. high, and up to the level of the top of these openings, the outer shell and lining are built together, the air space between them beginning at this point.

An interesting feature of the construction of this chimney was the use of slag from the matte furnaces of the smelters for the foundation blocks. An enormous mass of this material was formed on the site of the stack by pouring in molten slag from the smelters; this mass was made to cover a very much larger area of ground than the base of the stack and was stepped off at the edges in forming. It has an average depth of 12 ft. and contains reinforcements of steel rods around which the slag was poured while in molten state. The latter was used more for the purpose of tying the different courses together than for stiffening the mass, the material, while rather brittle and friable, possessing ample strength for the purpose and by the use of a waste product of the smelters, furnishing a very cheap foundation.

The base of the stack which is a low block of reinforced-concrete was spread to a bearing area 42½ ft. square to give a bearing pressure upon the slag foundation of less than 2,500 lb. per square foot; it rises as a square block for a height of 5 ft. above the foundation, while the upper 3 ft. of its height is a truncated pyramid. This base was formed of a 1:3:5 mixture of concrete and is reinforced in its lower face by two parallel nets of 1¼ x 1¼ x 3/16-in. tee-bars; the lower net work consists of two layers of 13 bars each, 12 in. above the bottom face, arranged horizontally on either diagonal from corner to corner for strengthening the corners and spaced on 12-in. centers, while the upper net-work consists of two layers of 20 bars each, arranged parallel to the sides of the base and equally spaced, the upper net-work being located about 36 in. above the lower net-work.



Details of the Smelter Chimney.

The vertical reinforcement of the chimney shaft, by means of which the bending forces caused by wind pressure are provided for, is in the Weber construction, extended into the base, being in the case of this chimney, as shown in the detail drawing of the base, carried in part down to a toe resting on the foundation block and in part, diagonally out to the edges of the base. For this reinforcement, 1¼ x 1¼ x 3/16-in. tee bars were used, as used in the base, for both the outer shell and the lining, for reason of the greater adjoining area for adhesion to the concrete than round or square rods. These bars are all inserted in the center of the shell section, there being 460 of the vertical bars in the first course of the outer shell, which bars extend up to a point 14½ ft. above the top of the base, the number of bars decreasing above this point in 10-ft. steps to a minimum number of 20 bars at the top. The decrease is by 20 bars to a step for the greater part, varying, however, in certain cases; at a point 120 ft. below the top, 40 bars are continued for 20 ft., thence 30 bars for 25 ft., while the remaining upper 75 ft. have 20 bars for the entire distance. The vertical bars are arranged in groups and joinings in continuous lines are arranged as irregular as possible in order to prevent many joints at one level. The vertical reinforcement of the lining, which is extended down but 2 ft. below the top of the base, except over the flue openings, consists of 20 vertical bars, all of which are carried up practically to the top of the lining. The reinforcement over the flue openings consists of extra rings and verticals, together with additional concrete in the air space which is filled 18 to 20 in. over them.

The vertical reinforcement is stayed laterally by steel rings formed of ⅝-in. round steel rods, bent to the proper circle and lapped at least 24 in., encircling the vertical bars at regular intervals. These rings are spaced 18 in. between centers in the lining and on 3-ft. centers in the outer shell, excepting for the first 20 ft. above the base, where, in the section around the flue openings that are without the air space, there are segments of the rings only, spaced 12 in. on centers. At the offset and in the head of the chimney, however, extra rings were placed to strengthen the shell at the change of section.

The concrete mixture for both the lining and the shell was formed of 1 part of Portland cement to 3 parts sand. It was machine mixed and well tamped by hand into the forms, which are of the special type used by the Weber Co. in the construction of its chimneys, by means of which the entire work of erection is done from the inside with no outside scaffolding.

In the calculations for the amounts of reinforcing steel necessary to provide for the bending stresses caused by wind pressure, a wind velocity of 100 miles per hour was provided for, which corresponds to a pressure of 50 lb. per square foot of flat surface, or 25 lb. per square foot on the projected area of the cylindrical surface. The stresses were analyzed at three sections in the outer shell, one at the top of the flue openings, the point at which the air space between the outer shell and the lining begins; the second a short distance below the offset, and the third at the top of the offset, where the single outer shell of decreased diameter begins. Considering first the shell with reference to the lowest section, the maximum total of wind pressure upon the structure above it, based on a pressure of 25 lb. per square foot of projected area of the shell was calculated at 154,522 lb., giving a wind moment at this section of 23,856,332 ft.-lb. The moment of resistance to tension in the shell, taken as the product of the radius of the neutral core into the calculated weight of the outer shell above this section (1,777,401 lb.), was figured at 8,709,265 ft.-lb., so that the resulting bending moment, the difference between the wind moment at this section and the moment of resistance to tension, is equal to 15,147,067 ft.-lb. The maximum tension per square inch in the shell at this section, which was taken as 12 times the quotient of the above bending moment by the section modulus at this point, was accordingly calculated as 451.5 lb., from which the total maximum tension in the shell at this section (area of section in square inches times tension per square inch) was found to be 3,101,913 lb. Upon this total maximum tension the total amount of steel reinforcement was based, the maximum allowable stress in the steel being taken as 16,000 lb. per square inch, which thus made 193.9 sq. in. of steel necessary. As the 1¼ x 1¼ x 3/16-in. tee-bars have a cross-sectional area of 0.45 sq. in., the number of bars theoretically required will be 431; instead, 460 bars were used at this section. The maximum compression at this section was determined as the sum of the pressure per square inch on the section due to the weight of the shell above it, and the maximum tension per square inch in the shell due to wind pressure, which was calculated at 710 lb. per square inch.

In the determination of the theoretical length necessary for each side of the square base, it was necessary to determine the wind moment at the base of the chimney, the quotient of which divided by the total weight of the chimney and multiplied by 6 gives the length desired. The wind moment at the base was calculated as the product of the total maximum wind pressure on the entire shell by the arm of wind moment at the top of the foundation, or 27,860,317 ft.-lb., the arm of wind moment at this point being the distance of the lowest section above foundation level, 26 ft., plus the arm of wind moment as referred to that section, which is 108.3 ft. This value of the moment applied to the above formulas gives the theoretical length at the side of the base as 40.4 ft., but for an ample factor of safety, the base was made 42½ ft. square.

A similar method of calculation was used for the determination of the number of vertical reinforcing bars at both of the upper sections considered, although amounts of steel considerably in excess of that calculated to be necessary were used. At the middle section, which is taken at a point 81½ ft. above the top of the base and 20 ft. below the top of the offset, the theoretical requirement was for 242 of the vertical tee-bars, while in actual construction 300 bars were used at this point. Similarly at the upper section, which was taken at the top of the offset, 232 bars were found to be required theoretically, whereas 260 were used in the construction. The weight of the chimney above the base, including lining, was calculated on the basis of 150 lb. per cubic foot for reinforced concrete, to be 2,273,445 lb.; that of the base was similarly calculated as 1,869,994 lb., so that the total weight upon the foundation is 4,143,439 lb., a bearing pressure of 2,302 lb. per square ft.

Letters to the Editor.

Treatment of Railroad Ties and Materials Available for this Purpose in New Jersey, Pennsylvania and New York.

Sir:—The article on the above subject, prepared by the writer and published in The Engineering Record for April 20, 1907, contains two slight errors to which Mr. Octave Chanute, of Chicago, has kindly called my attention, and since this article has apparently received considerable attention, you will doubtless be willing to correct the errors that have been made. The first correction referred to applies to paragraph "E" at the bottom of page 484 of that issue; it is evident that the statement of "one-half pound per cubic foot" made in this paragraph is in error, since for a tie 7 x 9 in. by 8½ ft., containing 3.72 cu. ft., there will be about 1 1/3 lb. of oil per cubic foot, and for a somewhat smaller tie, the quantity would run about 1½ lb. per cubic foot. On second reading, it is apparent that the writer's intention was that this should read "about 1½ lb. per cubic foot." In regard to the other point, Mr. Chanute has called attention to a statement made regarding the Zinc-Creosote Process used in Germany. According to the article, zinc-chloride is first injected and then the creosote is added by a second operation. Mr. Chanute states that the German concern using this process had faithfully tested the separate method, but had never been able to accomplish uniform results in that manner. This concern says that the only way to use the zinc-creosote process and get good results is to inject both substances simultaneously in an emulsion. Since Mr. Chanute is specially well posted on this subject, he is, no doubt, correct in his criticism in this connection.

Very truly yours,
L. Bush, Chief Engineer,
Delaware, Lackawanna & Western R. R.
Hoboken, N. J., May 28.

Garbage Disposal in Cleveland.

Sir:—The description of the design and operation of the garbage-disposal works in Cleveland that was printed in The Engineering Record of May 23 contains much that is of more than ordinary interest to municipal officials who have to do with similar works. Practically every city of any size in this country has had at least one sorrowful experience in regard to the provision of works to dispose of municipal wastes, and several of the larger cities have made various ineffectual attempts to devise some means of economically handling garbage and refuse. As a result, the mere mention of an advance in the design and operation of such works is usually as odious as the fumes that generally emanate from some of the latter. The highly satisfactory results obtained in the Cleveland plant will, therefore, naturally be received with some skepticism; but those engineers who have been fortunate enough to visit this plant, and a number have been afforded the opportunity, appreciate how carefully the details of its equipment have been developed and the business-like manner in which it is operated. Furthermore, this plant has received much extended study on the part of engineers for several cities in different parts of the country and, I understand, at least two cities, with prospect of one other, have designed plants similar to this one, with others apparently certain to follow. At the same time, the daily press at large has given considerable publicity to the results obtained. This latter phase of the situation may have one unfortunate outcome: the results obtained with the Cleveland plant, as featured by the different local papers, may lead the layman to believe that the methods used in that plant are a panacea for garbage troubles in all parts of the country, whereas it is perfectly evident that each individual case must be treated according to the conditions existing in connection with it, although the Cleveland results will furnish a good basis from which to start. It is quite certain, however, that an appreciation of this condition is realized by engineers. Very truly yours,

Chicago, May 28. H. S. T.

The Blackwell's Island Bridge.

Sir: The last two issues of your paper have taken the right position in respect to the unwarranted charges made concerning the Blackwell's Island Bridge, but it occurs to me that your comments have not been sufficiently detailed to give all the facts which a reader not directly interested in long-span bridge design may wish. I have accordingly ventured to send you the following statement of facts:

The original designs for this bridge were made by the Department of Bridges of New York City, under the direction of Mr. Gustav Lindenthal, when he was Commissioner of Bridges. After the contracts had been awarded and a portion of the substructure had been built, but before the superstructure was commenced, Mr. Lindenthal's official association with the work terminated. The new administration of the Department made a careful examination of the computations and plans, and reached the conclusion that abundant provision should be made for a material increase in the traffic over the structure. It was decided to provide for eight instead of six tracks on the superstructure, although it is not contemplated that the two additional ones will be needed at present. The design was accordingly revised to provide for this increase, but the changes were in no sense radical and did not alter the length, width, general dimensions or appearance of the superstructure. The added weight in the superstructure was due chiefly to the new tracks and to the steel required to provide for a corresponding increase in the strength of the trusses, the unit stresses of the latter being maintained as specified in Mr. Lindenthal's design.

The computations for this bridge, like those for other great bridges in New York, distinguished between probable loads and possible loads. In providing for the former conservative methods were used, and in providing for the latter care was taken to follow safe methods in determining and providing for the possible stresses that lie beyond the limits of reasonable expectation. In order to develop the highest possible unit stresses, certain portions of the span must be loaded to their utmost capacity on each of the eight tracks for long distances, while other intermediate portions must be entirely without any load. It is possible in this way to figure the theoretically possible stresses which have been provided for and are considerably in excess of those that would arise through the complete loading of all tracks of the whole structure. Obviously it is not believable that such traffic conditions will arise, either accidently or intentionally, but should they occur, the structure is calculated to have abundant strength under the stresses developed.

Considerable emphasis has been laid by newspaper critics on the statements that the allowed unit stresses in the bottom chords of the bridge are greater than those under which failure occurred in the Quebec Bridge. Such a statement is very mischievous in the misleading effect it is likely to have among laymen. Every structural engineer realizes that two columns made from identically the same material may have a safe strength varying 100 per cent. or more according to their design. A compression chord member of a given length, width and cross-sectional area may have a perfectly safe working stress of 30,000 lb. per square inch and another one of the same length, weight and cross-sectional area may be so designed that its safe working strength is not more than 10,000 lb. per square inch and it may fail at 15,000 or 20,000 lb. The case is the same as that of an imperfect rope which can easily be seen to break under a small load if it is so imperfectly twisted that first one strand and then another successively breaks without ever giving them an opportunity to act together as a whole.

The published assertion that the design of the bottom chords in the Blackwell's Island Bridge is distinctly inferior to that in the Quebec Bridge is unwarranted. The great element of weakness in the Quebec Bridge chord was the use of light lattice bars to connect the multiple webs. In the Blackwell's Island Bridge, latticing and tie-plates between the webs are supplemented by numerous heavy vertical transverse diaphragms which greatly increase the efficiency of the webs and develop much larger compressive strength in the finished member. The computations for the bridge have been checked and revised by different engineers in the Bridge Department and by the competent engineers of the contractor. These have been again scrupulously verified since the Quebec Bridge disaster, leaving no reasonable ground to doubt in any way the safety and efficiency of the structure under any of the conditions for which it has been designed.

That the erection of the great span has now been substantially completed, that the enormously increased temporary stresses due to the 625-ton traveler at the extremity of the cantilever arm, involving a tremendous moment which can never be repeated, have been endured without the slightest injury to the structure; that the connections between the cantilever arms have been successfully made, thus completing the crucial test which the Quebec Bridge unfortunately failed to sustain; that the deflections of the bridge are as theoretically calculated, thus verifying the computation; and that there are no evidences of weakness or distress in any of the members, although subject now to a large proportion of the stresses due to dead load, are sufficient assurance for the safety and integrity of the structure, the excellence of material, accuracy of workmanship and correctness of design. C. E.